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ORIGINAL ARTICLES.

I.—The Palæontographical Society of London.

(PLATE XIII.)

AMONGST the various interesting scientific events which this year has witnessed, none has probably been more heartily welcomed or more cordially honoured than the Jubilee of the Palæontographical Society, which was celebrated on the 19th June last.

The annual general meeting was held on that day, under the chairmanship of Dr. Henry Woodward, F.R.S., F.G.S. (the President-elect), at the rooms of the Geological Society, Burlington House; and the Council availed themselves of the occasion to give a brief account of the early history and subsequent progress of the Society.

The origin was mainly due to the prior issue of Sowerby's "Mineral Conchology," of which the first part appeared in June, 1812, and was followed by other parts for over thirty years. The portions of this work were brought out slowly and irregularly, and rarely illustrated more than ten species at one time. During the publication of this contribution to geological science, an association was formed (about the year 1836) called "The London Clay Club," the members of which were enthusiastic collectors of the shells of the Tertiary deposits in the neighbourhood of the Metropolis. At one of the meetings of the club about the year 1845, the late Dr. (then Mr.) J. S. Bowerbank suggested that as the "Mineral Conchology," at its then rate of issue, could not possibly depict all the British fossils within a moderate period, it would be well to have recourse to a new method. A proposition was immediately offered that subscriptions should be solicited for a larger and more complete publication. The idea was favourably received; Mr. Sowerby was asked to undertake the copper-plate engraving, and many geologists living in different parts of the country were communicated with. In the furtherance of this project, Mr. Bowerbank laboured with much zeal and energy. At the time it was considered that in five and twenty years all the British fossils would be figured.

On March 23, 1847, a meeting was held at the apartments of the Geological Society, Somerset House, with Sir Henry De la Beche

in the chair, when it was resolved that a Society be constituted, the object of which should be "to figure and describe as completely as possible a stratigraphical series of British fossils." The meeting further determined that the annual subscription should be one guinea, that the word Palæontographical should be the name, and that the Society should consist of a President, Treasurer, Secretary, and Council of sixteen members. On that day Sir Henry De la Beche was elected President, Mr. S. V. Wood, Treasurer, and Mr. (afterwards Professor) J. Morris, Secretary. The members of the first Council were Professor T. Bell, Mr. J. S. Bowerbank, Mr. F. E. Edwards, Sir P. Egerton, Dr. H. Falconer, Dr. W. H. Fitton, Mr. J. W. Flower, Prof. E. Forbes, Mr. S. B. Ibbetson, Mr. (afterwards Sir) C. Lyell, Prof. J. Phillips, Mr. (afterwards Sir) J. Prestwich, Mr. D. Sharpe, Mr. J. Smith, Mr. N. T. Wetherell, and Mr. A. White. Of these one alone survives, Prof. Sir J. Prestwich.[1] In the May of the same year, Prof. Morris sent in his resignation, and Mr. Bowerbank was appointed his successor.

The first Annual Report was read on the 23rd March, 1848, when it was stated that 640 names had been forwarded for membership, that 363 subscriptions had been received, and that the first volume, "The Univalves of the Crag," by Mr. S. V. Wood, was ready for delivery. This book contains the earliest list of members, and shows that 568 persons and thirty libraries were entered on the list at that date.

On August 14, 1848, a report was presented to a special meeting at Swansea (where the British Association was assembled), in which it was mentioned that offers of monographs had been made on the Conchifera and Foraminifera of the Crag, the Shells of the London Clay, the fossil Reptilia of Great Britain, the Crustacea of the London Clay, the Corals of the Secondary formations, the Shells of the Fresh-water formation above the Crag, the Tertiary Shells of the Clyde, the Spongiadæ of the Chalk formation, the Fossils of the Magnesian Limestone, the Belemnites of the British formations, the Fossil Testacea of the Great Oolite, and the Entomostracous animals of the Chalk, Gault, and Greensand.

In the second Annual Report, read 23rd March, 1849, there is evidence that the Society had become established. The local secretaries are spoken of as being forty in number, and the enrolled members as many as 732. It is added that 615 persons had paid for the first volume, and that the receipts for the years 1848–9 were (irrespective of the balance from the previous year) £690 19*s*. Each succeeding year realized larger funds, until the maximum was reached in 1867, when over 800 subscribers had joined the Society. It is remarkable how many persons must have been enrolled as subscribers during the past forty-nine years, seeing that the whole of the original members have, with eight exceptions, passed away. Four of these are still subscribers. At present the subscriptions from Libraries exceed those from private individuals in the proportion

[1] Sir Joseph Prestwich died at his residence, Darent Hulme, Shoreham, Kent, a few days after the anniversary, namely, on 23rd June, 1896.

of about 8 to 7. This change, so different to what had been the case in the beginning, is mainly due to the fact that of late years strong efforts have been made to secure the accession of the Free Libraries.

Of the officers of the Society the Presidents have been five: Sir Henry De la Beche, from 1847 to 1855; Mr. W. J. Hamilton, from 1856 to 1867; Dr. Bowerbank, from 1865 to 1876; Sir R. Owen, from 1877 to 1892; and Professor Huxley, from 1893 to 1895. The Treasurers have been two: Mr. S. V. Wood, from 1847 to 1884, and Mr. R. Etheridge, from 1885 to the present time. The Secretaries have been three: Professor Morris, for two months in 1847, Dr. Bowerbank, from 1847 to 1862, and the Rev. Professor Wiltshire, from 1863 to the present time.

The publications of the Society have covered a large area of information, comprehending the fossil Plantæ, etc., fossils from the subkingdoms Protozoa, Porifera, Cœlenterata, Echinodermata, Annulosa, Mollusca, and Vertebrata.

Monographs have been completed on the Morphology of *Stigmaria ficoides*, the Ferns and Gymnosperms of the Eocene beds, the Foraminifera of the Carboniferous and Permian deposits, the Stromatoporoids, the fossil Corals, the Polyzoa of the Crag, the fossil Cirripedia, the Post-Tertiary, Tertiary, and Cretaceous Entomostraca, the fossil Estheriæ, the Trilobites, the fossil Merostomata, the fossil Brachiopoda, the Mollusca of the Crag, Eocene, and Great Oolite, the fossil Trigoniæ, the Cretaceous and Oolitic Echinodermata, the Lias Ammonites, the Permian fossils, the Tertiary, Cretaceous, Wealden, Purbeck, Kimmeridge Clay, and Lias Reptilia, the Red Crag Mammalia, the Mesozoic Mammalia, and the fossil Elephants.

Monographs are in progress on the Foraminifera of the Crag, the fossil Sponges, the Cretaceous Starfishes, the Carboniferous Mollusca, the Inferior Oolite Ammonites, the Fishes of the Old Red Sandstone, the Pleistocene Mammalia, and the Devonian Fauna.

At an early date monographs will be commenced on the fossil Cycadeæ, the Cretaceous Mollusca, and the Lias Gasteropoda, but many years must pass away before the whole of the British fossils are described, and the intention of the original founders of the Society fulfilled.

The fiftieth volume, for 1896, has the whole of its plates ready and more than three-fourths of its text printed off. Its contents will comprise the continuation of the monographs on the Crag Foraminifera, the Anthracomyæ, and the Devonian Fauna, the commencement of a monograph on the Carboniferous Mollusca, and the conclusion of the monograph on the Inferior Oolite Gasteropoda.

Within a week of the last annual meeting, Professor the Right Hon. T. H. Huxley (then President) passed away. The Council suggest that Dr. Henry Woodward, F.R.S., be elected President, that the vacant Vice-Presidentship be conferred on the Rev. G. F. Whidborne, that Mr. R. Etheridge, F.R.S., be re-elected Treasurer, and the Rev. Prof. Wiltshire, Secretary; that the retiring members of Council be Sir W. Flower, Prof. Liveing, and the Rev. H. H.

Winwood (Capt. Tyler having recently died), and that the new members of Council be the Rev. R. A. Bullen, Rev. A. Fuller, Dr. W. Hind, and Mr. J. E. Marr, F.R.S. (The Report was adopted *nem. con.*)

Referring to the past publications issued by the Society, it appears that they give to the annual subscriber more than an average of 280 pages of quarto letterpress, accompanied by an average of 38 quarto plates, with 700 figures in the plates and text, and yield an *average* of 134 described species to each volume. This is far and away beyond what has yet been accomplished by any Continental Palæontographical Society for a subscription of one guinea annually.

If anyone desires to know how so much valuable scientific matter can be obtained for so small a sum, we will reveal to the anxious inquirer and would-be annual subscriber the secret.

(1) The Authors of monographs are not paid for their contributions.

(2) The Officers cheerfully give their services, so that the cost of management is reduced to a mere bagatelle.

(3) The Geological Society of London most generously gives to the Palæontographical Society room for their stock in its apartments at Burlington House *free of charge*, and also allows them to hold their meetings in its rooms.

(4) So that almost the entire cost of the volumes issued is confined to the drawing and printing of plates, to the setting up and correcting the letterpress, and the printing, paper, and binding of the annual volumes.

We sincerely trust that, with the new volume, will also come many new members, who will eagerly desire to obtain, not only the newly printed "annual" as it appears, but ask for and secure the back volumes, some of which may still be had (with a liberal allowance for taking a series) on application to the Honorary Secretary, the Rev. Prof. Wiltshire, M.A., F.G.S., 25, Granville Park, Lewisham, near London, S.E.

The accompanying Plate XIII, from a photograph taken at Mr. Frederick Edwards' house, Hampstead, about 1856, represents four of the original members of the Society, namely: Sir Joseph Prestwich, M.A., D.C.L., F.R.S., F.G.S.; Prof. John Morris, F.G.S.; F. E. Edwards, Esq., F.G.S.; and Searles V. Wood, Esq., F.G.S.[1]

II.—Classification of Dinosaurs.[2]

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.;
of Yale College, New Haven, U.S.A.

IN the present review of the Dinosaurs, I have confined myself mainly to the type specimens which I have described, but have included with them other important remains where these were

[1] Professor Morris, Mr. F. E. Edwards, and Mr. S. V. Wood also contributed monographs.

[2] From the American Journal of Science, vol. L, pp. 491–8.

available for investigation. The extensive collections in the museum of Yale University contain so many of the important type specimens now known from America, that they alone furnish an admirable basis for classification, and it was upon these mainly that I first established the present system, which has since been found to hold equally good for the Dinosaurs discovered elsewhere. In the further study of these reptiles, it was also necessary to examine both the European forms and those from other parts of the world, and I have now studied nearly every known specimen of importance. These investigations have enabled me to make this classification more complete, and to bring it down to the present time.

Many attempts have been made to classify the Dinosaurs, the first being that of Hermann von Meyer, in 1830. The name Dinosauria, proposed for the group by Owen, in 1839, has been generally accepted, although not without opposition. Hæckel, Cope, and Huxley followed, the last in 1869 proposing the name Ornithoscelida for the order, and giving an admirable synopsis of what was then known of these strange reptiles and their affinities. Since then, Hulke, Seeley, and Lydekker, Gaudry, Dollo, Baur, and many others, have added much to our knowledge of these interesting animals. The remarkable discoveries in North America, however, have changed the whole subject, and in place of fragmentary specimens, many entire skeletons of Dinosaurian reptiles have been brought to light, and thus definite information has replaced uncertainty, and rendered a comprehensive classification for the first time possible.

The system of classification I first proposed in 1881 has been very generally approved, but a few modifications have been suggested by others that will doubtless be adopted. This will hardly be the case with several radical changes recently advocated, based mainly upon certain theories of the origin of Dinosaurs. At present these theories are not supported by a sufficient number of facts to entitle them to the serious consideration of those who have made a careful study of these reptiles, especially the wonderful variety of forms recently made known from America.

Further discoveries may in time solve the problem of the origin of all the reptiles now called Dinosaurs, but the arguments hitherto advanced against their being a natural group are far from conclusive. The idea that the Dinosauria belong to two or more distinct groups, each of independent origin, can at present claim equal probability only with a similar suggestion recently made in regard to mammals. This subject of the origin of the Dinosaurs and the relation of their divisions to each other will be more fully treated by me elsewhere.

A classification of any series of extinct animals is of necessity, as I have previously said, merely a temporary convenience, like the bookshelves in a library, for the arrangement of present knowledge. In view of this fact and of the very limited information we now have in regard to so many Dinosaurs known only from fragmentary remains, it will suffice for the present, or until further evidence is forthcoming, to still consider the Dinosauria as a sub-class of the great group of Reptilia.

Regarding, then, the Dinosaurs as a sub-class of the Reptilia, the forms best known at present may be classified as follows :—

Sub-class Dinosauria, Owen.

Premaxillary bones separate; upper and lower temporal arches; no teeth on palate; rami of lower jaw united in front by cartilage only. Neural arches of vertebræ joined to centra by suture; cervical and thoracic ribs double-headed; ribs without uncinate processes; sacral vertebræ united; caudal vertebræ numerous; chevrons articulated intervertebrally. Scapula elongate; no precoracoid; clavicles wanting. Ilium prolonged in front of the acetabulum; acetabulum formed in part by pubis; ischia meet distally on median line. Fore and hind limbs present, the latter ambulatory and larger than those in front. Head of femur at right angles to condyles; tibia with procnemial crest; fibula complete; first row of tarsals composed of astragalus and calcaneum only, which together form the upper portion of ankle joint; reduction in number of digits begins with the fifth.

Order Theropoda (Beast foot). Carnivorous.

Skull with external narial openings lateral; large antorbital vacuity; brain case incompletely ossified; no pineal foramen; premaxillaries with teeth; no predentary bone; dentary without coronoid process; teeth with smooth compressed crowns and crenulated edges. Vertebræ more or less cavernous; posterior trunk vertebræ united by diplosphenal articulation. Each sacral rib supported by two vertebræ; diapophyses distinct from sacral ribs; sternum unossified. Pubes projecting downward and united distally; no postpubis. Fore limbs small; limb bones hollow; astragalus closely applied to tibia; feet digitigrade; digits with prehensile claws; locomotion mainly bipedal.

(1) Family *Megalosauridæ*. Lower jaws with teeth in front. Anterior vertebræ convexo-concave; remaining vertebræ biconcave; five sacral vertebræ. Abdominal ribs. Ilium expanded in front of acetabulum; pubes slender. Femur longer than tibia; astragalus with ascending process; five digits in manus and four in pes.

Genus *Megalosaurus* (*Poikilopleuron*). Jurassic and Cretaceous. Known forms European.

(2) Family *Dryptosauridæ*. Lower jaws with teeth in front. Cervical vertebræ opisthocœlian; remaining vertebræ biconcave; sacral vertebræ less than five. Ilium expanded in front of acetabulum; distal ends of pubes coössified and much expanded; an interpubic bone. Femur longer than tibia; astragalus with ascending process; fore limbs very small, with compressed prehensile claws.

Genera *Dryptosaurus* (*Lælaps*), *Allosaurus*, *Cœlosaurus*, *Creosaurus*. Jurassic and Cretaceous. All from North America.

(3) Family *Labrosauridæ*. Lower jaws edentulous in front. Cervical and dorsal vertebræ convexo-concave; centra cavernous

or hollow. Pubes slender, with anterior margins united; an interpubic bone. Femur longer than tibia; astragalus with ascending process.

Genus *Labrosaurus*. Jurassic, North America.

(4) Family *Plateosauridæ* (*Zanclodontidæ*). Vertebræ biconcave; two sacral vertebræ. Ilium expanded behind acetabulum; pubes broad, elongate plates, with anterior margins united; no interpubic bone; ischia expanded at distal ends. Femur longer than tibia; astragalus without ascending process. Five digits in manus and pes.

Genera *Plateosaurus* (*Zanclodon*), *? Teratosaurus*, *Dimodosaurus*. Triassic. Known forms European.

(5) Family *Anchisauridæ*. Skull light in structure, with recurved cutting teeth. Vertebræ biconcave. Bones hollow. Ilium expanded behind acetabulum; pubes rod-like and not coössified distally; no interpubic bone. Fore limbs well developed; femur longer than tibia; astragalus without ascending process; five digits in manus and four in pes. (Figure 1.)

Fig. 1.—Anchisaurus colurus, Marsh. $\frac{1}{24}$. Triassic, Connecticut.

Genera *Anchisaurus* (*Megadactylus*), *Ammosaurus*, *? Arctosaurus*, *Bathygnathus*, and *Clepsysaurus*, in North America; and in Europe, *Palæosaurus*, *Thecodontosaurus*. All known forms Triassic.

Sub-order Cœluria (Hollow tail).

(6) Family *Cœluridæ*. Teeth much compressed. Vertebræ and bones of skeleton very hollow or pneumatic; neural canal much expanded; anterior cervical vertebræ convexo-concave; remaining vertebræ biconcave; cervical ribs coössified with vertebræ. An interpubic bone. Femur shorter than tibia; metatarsals very long and slender.

Genera *Cœlurus*, in North America; and *Aristosuchus*, in Europe Jurassic.

Sub-order COMPSOGNATHA.

(7) Family *Compsognathidæ*. Skull elongate, with slender jaws and pointed teeth. Cervical vertebræ convexo-concave; remaining vertebræ biconcave. Ischia with long symphysis on median line. Bones very hollow. Femur shorter than tibia; astragalus with long ascending process; three functional digits in manus and pes.

Genus *Compsognathus*. Jurassic. Only known specimen European. (Figure 2.)

FIG. 2.—COMPSOGNATHUS LONGIPES, Wagner. $\frac{1}{8}$. Jurassic, Bavaria.

Sub-order CERATOSAURIA (Horned saurians).

(8) Family *Ceratosauridæ*. Horn on skull; teeth large and trenchant. Cervical vertebræ plano-concave; remaining vertebræ

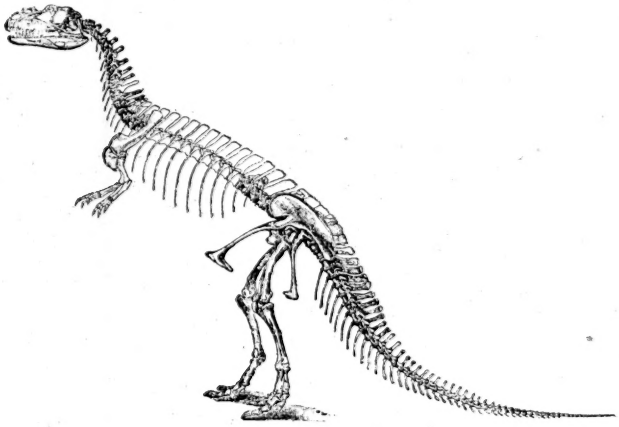


FIG. 3.—CERATOSAURUS NASICORNIS, Marsh. $\frac{1}{60}$. Jurassic, Colorado.

biconcave. Pelvic bones coössified; ilium expanded in front of acetabulum; pubes slender; an interpubic bone; ischia slender, with distal ends coössified. Limb bones hollow; manus with four digits; femur longer than tibia; astragalus with ascending process; metatarsals coössified; three digits only in pes. Osseous dermal plates. (Figure 3.)

Genus *Ceratosaurus*. Jurassic, North America.

(9) Family *Ornithomimidæ*. Pelvic bones coössified with each other and with sacrum; ilium expanded in front of acetabulum. Limb bones very hollow; fore limbs very small; digits with very long, pointed claws; hind limbs of true avian type; femur longer than tibia; feet digitigrade and unguiculate.

Genus *Ornithomimus*. Cretaceous, North America.

Sub-order HALLOPODA (Leaping foot).

(10) Family *Hallopidæ*. Vertebræ and limb bones hollow; vertebræ biconcave; two vertebræ in sacrum; acetabulum formed by ilium, pubis, and ischium; pubes rod-like, projecting downward, but not coössified distally; no postpubis; ischia with distal ends expanded, meeting below on median line. Fore limbs very small, with four digits in manus. Femur shorter than tibia; hind limbs very long, with three digits only in pes, and metatarsals greatly elongated; astragalus without ascending process; calcaneum much produced backward; feet digitigrade, unguiculate.

Genus *Hallopus*. Jurassic, North America.

Order SAUROPODA (Lizard foot). Herbivorous.

External nares at apex of skull; premaxillary bones with teeth; teeth with rugose crowns more or less spoon-shaped; large antorbital openings; no pineal foramen; alisphenoid bones; brain case ossified; no columellæ; postoccipital bones; no predentary bone; dentary without coronoid process. Cervical ribs coössified with vertebræ; anterior vertebræ opisthocœlian, with neural spines bifid; posterior trunk vertebræ united by diplosphenal articulation; presacral vertebræ hollow; each sacral vertebra supports its own transverse process, or sacral rib; no diapophyses on sacral vertebræ; neural cavity much expanded in sacrum; first caudal vertebra procœlian. Sternal bones parial; sternal ribs ossified. Ilium expanded in front of acetabulum; pubes projecting in front, and united distally by cartilage; no postpubis. Limb bones solid; fore and hind limbs nearly equal; metacarpals longer than metatarsals; femur longer than tibia; astragalus not fitted to end of tibia; feet plantigrade, ungulate; five digits in manus and pes; second row of carpal and tarsal bones unossified; locomotion quadrupedal.

(1) Family *Atlantosauridæ*. A pituitary canal; large fossa for nasal gland. Distal end of scapula not expanded. Sacrum hollow; ischia directed downward, with expanded extremities meeting on median line. Anterior caudal vertebræ with lateral cavities; remaining caudals solid.

Genera *Atlantosaurus*, *Apatosaurus*, *Barosaurus*, *Brontosaurus*. Include the largest known land animals. Jurassic, North America. (Figure 4.)

(2) Family *Diplodocidæ*. External nares superior; no depression for nasal gland; two antorbital openings; large pituitary fossa; dentition weak, and in front of jaws only; brain inclined backward; dentary bone narrow in front. Ischia with shaft not expanded distally, directed downward and backward, with sides meeting on median line. Sacrum hollow. Caudal vertebræ deeply excavated below; chevrons with both anterior and posterior branches.

Genus *Diplodocus*. Jurassic, North America.

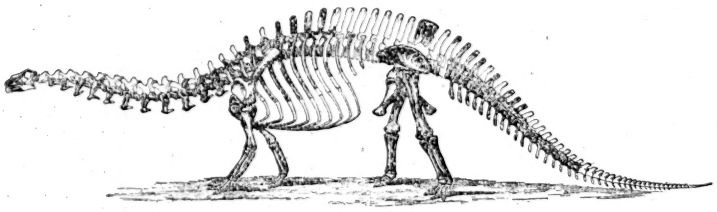


Fig. 4.—Brontosaurus excelsus, Marsh. $\frac{1}{180}$. Jurassic, Wyoming.

(3) Family *Morosauridæ*. External nares lateral; large fossa for nasal gland; small pituitary fossa; dentary bone massive in front. Shaft of scapula expanded at distal end. Sacral vertebræ nearly solid; ischia slender, with twisted shaft directed backward, and sides meeting on median line. Anterior caudals solid.

Genera *Morosaurus*, *? Camarasaurus* (*Amphicœlias*). Jurassic, North America.

(4) Family *Pleurocœlidæ*. Dentition weak; teeth resembling those of *Diplodocus*. Cervical vertebræ elongated; centrum hollow, with large lateral openings; sacral vertebræ solid, with lateral depressions in centra; caudal vertebræ solid; anterior caudals with flat articular faces, and transversely compressed neural spines; middle caudal vertebræ with neural arch on front half of centrum. Ischia with compressed distal ends, meeting on median line.

Genus *Pleurocœlus*. ? Jurassic, North America.

(5) Family *Titanosauridæ*. Fore limbs elongate; coracoid quadrilateral. Presacral vertebræ opisthocœlian; first caudal vertebra biconvex; remaining caudals procœlian; chevrons open above.

Genera *Titanosaurus* and *Argyrosaurus*. ? Cretaceous, India and Patagonia.

(6) Family *Cardiodontidæ*. Teeth of moderate size. Upper end of scapula expanded; humerus elongate; fore limbs nearly equalling hind limbs in length. Sacrum solid; ischia with wide distal ends meeting on median line. Caudal vertebræ biconcave.

Genera *Cardiodon* (*Cetiosaurus*), *Bothriospondylus*, *Ornithopsis*, and *Pelorosaurus*. European, and probably all Jurassic.[1]

Order PREDENTATA. Herbivorous.

Narial opening lateral; no antorbital foramen; brain case ossified; supra-orbital bones; teeth with sculptured crowns; maxillary teeth with crowns grooved on outside; lower teeth with grooves on inside of crown; a predentary bone; dentary with coronoid process. Cervical ribs articulating with vertebræ; each sacral rib supported by two vertebræ. Ilium elongated in front of acetabulum; prepubic bones free in front; postpubic bones present; ischia slender, directed backward, with distal ends meeting side to side. Astragalus without ascending process.

Sub-order STEGOSAURIA (Plated lizard).

Skull without horns; no teeth in premaxillaries; teeth with distinct compressed crowns and serrated edges. Fore limbs small.

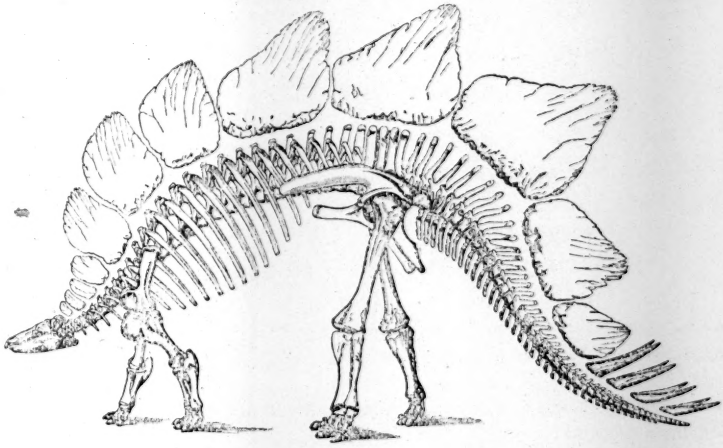


FIG. 5.—STEGOSAURUS UNGULATUS, Marsh. $\frac{1}{60}$. Jurassic, Wyoming.

Vertebræ and limb bones solid. Pubes projecting free in front; postpubis present. Femur longer than tibia; feet plantigrade, ungulate; five digits in manus and four in pes; second row of carpals and tarsals unossified; locomotion mainly quadrupedal. Osseous dermal armour.

(1) Family *Stegosauridæ*. Vertebræ biconcave. Neural canal in sacrum expanded into large chamber; ischia directed backward, with sides meeting on median line. Dorsal ribs T-shaped in cross section. Astragalus coössified with tibia; metapodials very short; five digits in manus; three functional digits in pes. Back surmounted by a crest of vertical plates; tail armed with one or more pairs of large spines. (Figure 5.)

[1] The Wealden is here regarded as Upper Jurassic, and not Cretaceous. See O. C. Marsh, GEOL. MAG., Decade IV, Vol. III, 1896, p. 8; and A. S. Woodward, pp. 69–71, "On the Affinities of the Wealden Fauna and Flora."

Genera *Stegosaurus* (*Hypsirhophus*), *Diracodon*, *? Dystrophæus*, *Palæoscincus*, *Priconodon*, all from North America; and in Europe, *Omosaurus*, Owen. Jurassic and Cretaceous.

(2) Family *Scelidosauridæ*. Neural canal narrow; diapophysis of dorsal vertebræ supporting head and tubercle of ribs. Astragalus not coössified with tibia; metatarsals elongated; three functional digits in pes.

Genera *Scelidosaurus*, *Acanthopholis*, *Hylæosaurus*, *Polacanthus*. Jurassic and Cretaceous. Known forms all European. (Figure 6.)

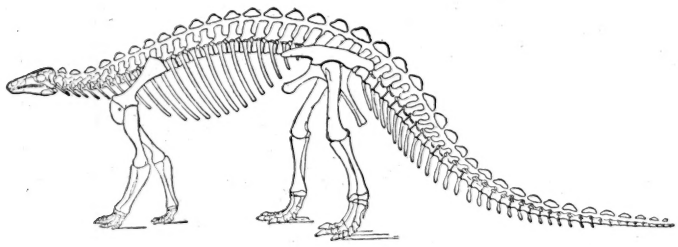


Fig. 6.—Scelidosaurus Harrisoni, Owen. $\frac{1}{36}$. Jurassic, England.

(3) Family *Nodosauridæ*. Heavy dermal armour. Bones solid. Fore limbs large; feet ungulate.

Genus *Nodosaurus*. Cretaceous, North America.

Sub-order Ceratopsia (Horned face).

Premaxillaries edentulous; teeth with two distinct roots; skull surmounted by massive horn-cores; a rostral bone, forming a sharp, cutting beak; expanded parietal crest, with marginal armature; ? a pineal foramen. Vertebræ and limb bones solid; fore limbs large; femur longer than tibia; feet ungulate; locomotion quadrupedal. Dermal armour.

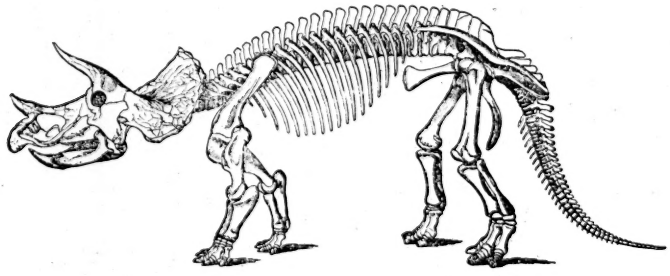


Fig. 7.—Triceratops prorsus, Marsh. $\frac{1}{80}$. Cretaceous, Wyoming.

(4) Family *Ceratopsidæ*. Anterior cervical vertebræ coössified with each other; posterior dorsal vertebræ supporting on the diapophysis both the head and tubercle of the rib; lumbar vertebræ

wanting; sacral vertebræ with both diapophyses and ribs. Pubes projecting in front, with distal end expanded; postpubic bone rudimentary or wanting.

Genera *Ceratops, Agathaumas, Monoclonius, Polyonax, Sterrholophus, Torosaurus, Triceratops,* in North America; and in Europe, *Struthiosaurus* (*Cratæomus*). All are Cretaceous. (Figure 7.)

Sub-order ORNITHOPODA (Bird foot).

Skull without horns; premaxillaries edentulous in front. Vertebræ solid. Pubes projecting free in front; postpubis present. Fore limbs small; astragalus closely fitting to end of tibia; feet digitigrade; three to five functional digits in manus and three to four in pes; locomotion mainly bipedal. No dermal armour.

(5) Family *Camptosauridæ* (*Camptonotidæ*). Premaxillaries edentulous; teeth in single row; a supra-orbital fossa. Anterior

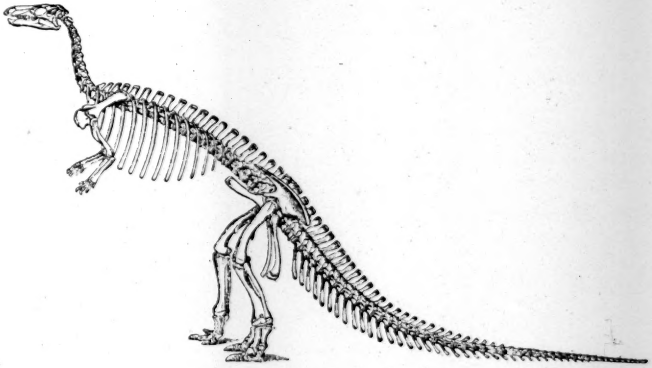


FIG. 8.—CAMPTOSAURUS DISPAR, Marsh. $\frac{1}{60}$. Jurassic, Wyoming.

vertebræ opisthocœlian; sacral vertebræ with peg and notch articulation. Limb bones hollow; fore limbs small; five digits in manus. Postpubis reaching to the distal end of ischium. Femur longer than tibia, and with pendent fourth trochanter; hind feet with four digits. (Figure 8.)

Genus *Camptosaurus* (*Camptonotus*). Jurassic, North America.

(6) Family *Laosauridæ*. Premaxillaries edentulous; teeth in single row. Anterior vertebræ with plane articular faces; sacral vertebræ coössified. Sternum unossified. Postpubis reaching to distal end of ischium. Limb and foot bones hollow; fore limbs very small; five digits in manus; femur shorter than tibia; metatarsals elongate; four digits in pes.

Genera *Laosaurus* and *Dryosaurus*. Jurassic, North America. (Figure 9.)

(7) Family *Hypsilophodontidæ*. Premaxillaries with teeth; teeth in single row; sclerotic bony plates. Anterior vertebræ opistho-

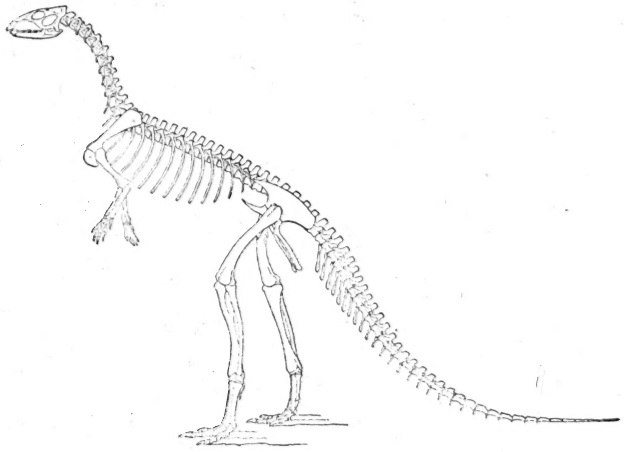


FIG. 9.—LAOSAURUS CONSORS, Marsh. $\frac{1}{20}$. Jurassic, Wyoming.

cœlian; sacral vertebræ coössified. Sternum ossified. Postpubis extending to end of ischium. Limb bones hollow; five digits in manus; femur shorter than tibia; hind feet with four digits.

Genus *Hypsilophodon*. Wealden, England. (Figure 10.)

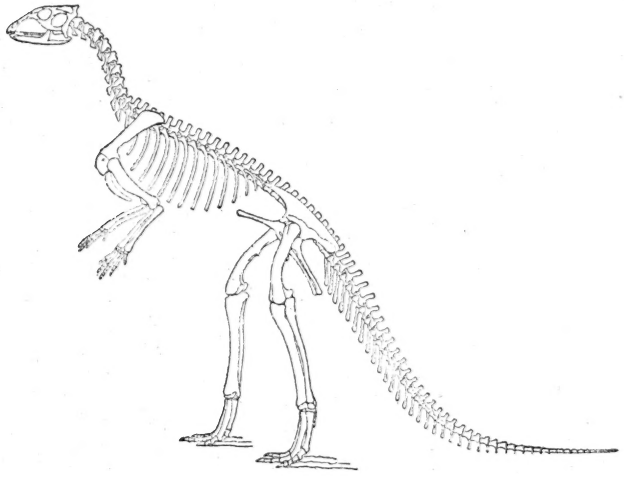


FIG. 10.—HYPSILOPHODON FOXII, Huxley. $\frac{1}{16}$. Cretaceous, England.

(8) Family *Iguanodontidæ*. Premaxillaries edentulous; teeth in single row. Anterior vertebræ opisthocœlian. Manus with five

digits; pollex spine-like. Sternal bones ossified. Postpubis incomplete. Femur longer than tibia. (Figure 11.)

Genera *Iguanodon, Vectisaurus.* Jurassic and Cretaceous. Known forms all European.

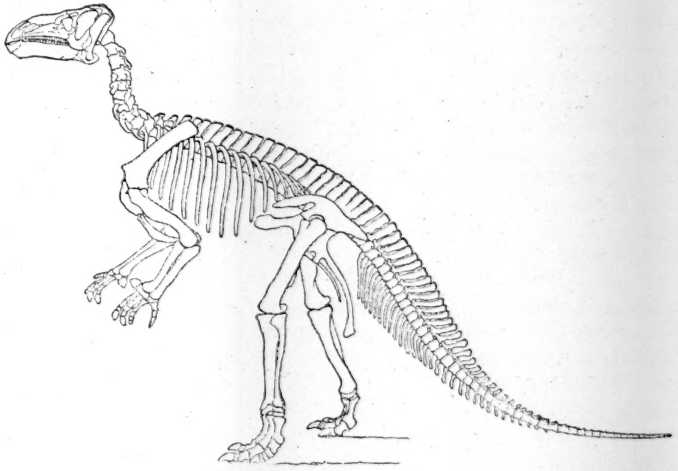


FIG. 11.—IGUANODON BERNISSARTENSIS, Boulenger. $\frac{1}{80}$. Cretaceous, Belgium.

(9) Family *Trachodontidæ* (*Hadrosauridæ*). Premaxillaries edentulous; teeth in several rows, forming with use a tessellated grinding surface. Cervical vertebræ opisthocœlian. Limb bones hollow; fore limbs small; femur longer than tibia.

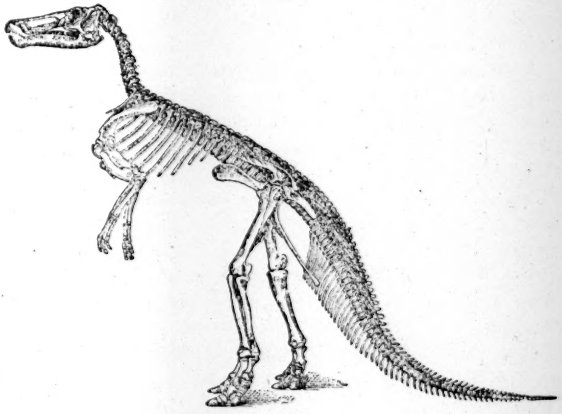


FIG. 12.—CLAOSAURUS ANNECTENS, Marsh. $\frac{1}{80}$. Cretaceous, Wyoming.

Genera *Trachodon* (*Hadrosaurus, Diclonius*), *Cionodon.* Cretaceous, North America.

(10) Family *Claosauridæ*. Premaxillaries edentulous; teeth in several rows, but a single row only in use. Cervical vertebræ opisthocœlian. Limb bones solid; fore limbs small. Sternal bones parial. Postpubis incomplete. Femur longer than tibia; feet ungulate; three functional digits in manus and pes. (Figure 12.)

Genus *Claosaurus*. Cretaceous, North America.

(11) Family *Nanosauridæ*. Teeth compressed and pointed, and in a single, uniform row. Cervical and dorsal vertebræ short and biconcave; sacral vertebræ three. Ilium with very short pointed front, and narrow posterior end. Limb bones and others very hollow; fore limbs of moderate size; humerus with strong radial crest; femur curved, and shorter than tibia; fibula pointed below; metatarsals very long and slender. Anterior caudals short.

Genus *Nanosaurus*. Jurassic, North America. Includes the smallest known Dinosaurs.

In these restorations of Dinosaurian Reptiles the scientific name, the size, geological formation, and country where found, are given under each of the twelve figures. The skeletons here restored are represented in the same general position, to aid in comparing them with each other.

III.—On a Pebbly Quartz-Schist from the Val d'Anniviers (Pennine Alps).

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.

In 1893 I described in this Magazine[1] a group of quartz-schists which may be traced for many miles along the Alps—a group belonging to the series which appear to be the newest among the crystalline schists of that chain. I may refer to this paper for a description of their mode of occurrence, distribution, and structure, both macroscopic and microscopic, merely stating that, while considering them to have had a clastic origin—in other words, to be metamorphosed sandstones—I pointed out that they presented some material differences from ordinary quartzites, and that "original fragments [could not] be distinguished with certainty in any of them," though "here and there a clastic structure," of which I gave instances, "may be suspected."

In 1894 my friend Mr. J. Eccles, F.G.S., informed me, on his return from the Alps, that he had discovered pebbles in this quartz-schist in the Val d'Anniviers (Einfisch-thal),[2] showing me specimens of the rocks. I examined one of these under the microscope, and the results fully confirmed his determination in the field. This pebbly schist, he said, occurred on the western flank of the range between the Val d'Anniviers and the Turtman-thal, in an upland glen of the Tounot, about one-third of a mile ESE. of the

[1] Geol. Mag., Dec. III, Vol. X, pp. 204–210.

[2] It is the second valley to the west of the Vispthal, opening into the Rhône Valley opposite to Sierre.

well-known Weisshorn Hotel. As any indication of a coarse clastic structure in a true crystalline schist, so far as I knew, was a rarity, I determined to examine this rock in the field the next time that I happened to visit that part of the Alps. An opportunity presented itself during the summer of last year, when I had the good fortune to be accompanied by Mr. Eccles himself, as well as by another fellow-worker in Alpine geology, the Rev. E. Hill. We had intended to spend a week or two at Zinal, and therefrom to visit the sections discovered by Mr. Eccles, which can be reached by a rather long walk over the rough slopes of the range on the eastern side of Val d'Anniviers. This intention, however, was afterwards abandoned, as we found plenty of a similar rock in much more accessible situations.

The torrent from the Val d'Anniviers enters the Rhone Valley through a deep and narrow gorge. Thus a considerable ascent must be made in order to gain the slopes above it; and the road to Zinal, before entering the actual valley, mounts in a series of zigzags up its eastern portal from the level of the Rhone. As we ascended,[1] I passed the following rocks on the slopes: (1) rauchwacke, (2) a dark slaty rock, (3) *Pontiskalk*, (4) *Casanna Schiefer*; the outcrops not necessarily occurring in this order. The first of these four is the usual buff-coloured friable limestone, so common in the Alps (though often in patches only), which is generally admitted to be Triassic in age; the second, also, is a type not uncommon in the Alps—a black slate or phyllite, assigned to the Carboniferous system; the third is a more or less calcareous rock, rather variable in colour and character, but often a greyish or darkish limestone, in places subcrystalline, but very different in aspect from the calc-schists which are so largely developed in the Pennine chain a little further to the south, and are associated with the above-named quartz-schists. This *Pontiskalk* I believe to be more modern than the crystalline schists, and think it may belong to some part of the Palæozoic era. The fourth, the *Casanna Schiefer*, is a gneissic rock, not very coarse in texture, often considerably crushed, fairly micaceous, and generally of a dullish grey colour. A rock of a similar character often appears, in this region of the Alps, to underlie the aforesaid group of crystalline schists.

The floor, as it may be called, of the Val d'Anniviers is gained after an ascent of about 1300 feet, not far from Niouc, and about $3\frac{1}{2}$ miles beyond is Fang. Before reaching the latter hamlet, blocks of quartz-schist became abundant by the roadside, and it was soon evident that ample materials for study were close at hand, for many of them indubitably contained pebbles. Further examination showed that a great talus of these blocks extended up for some hundreds of feet to the foot of a cliff, obviously of the same rock. To this, however, we did not ascend, as we perceived that we should cross its outcrop higher up the valley. On reaching this we found good sections, and afterwards we discovered indications of

[1] An old mule path cuts off some of the zigzags of the carriage road. I have traversed both routes.

pebbles, though not often, in the quartz-schist near Zinal. Time will be saved by collecting together the results of our examination of the different sections.

This quartz-schist, according to the Geological Survey Map of Switzerland (*Blatt.* xvii and xxii), occurs in several localities on either side of the Val d'Anniviers, coming generally immediately above the *Casanna Schiefer*. It is overlain by a thick mass of schist, which for brevity I will designate calc-mica-schist,[1] though it may vary from an almost pure marble (rare) to a very slightly calcareous mica-schist; the latter being the more usual type in this valley. With these schists we find a third type, called on the map *Grüner Schiefer*, which may be an intrusive igneous rock, subsequently modified by pressure. As there shown, the quartz-schist strikes, very roughly speaking, from ENE. to WSW. In the lower part of the Val d'Anniviers it is dipping at a moderate angle towards the south,[2] and its outcrop rises rather rapidly up the mountain slopes on either side. Proceeding along the crests of these towards the same point of the compass, we see from the map that the quartz-schist occurs at intervals above the *Casanna Schiefer*, at elevations varying approximately from 8,800 to 9,800 feet above the sea. Presently, in the peaks of the Tounot and Roc de Budry (10,302′) on the east side, and in the Becs de Bosson (10,386′) on the west, it is capped by calc-schist. Then, south of the former, comes a slight interruption, for the Forcletta Pass (9,810′) is cut down to the *Casanna Schiefer*, and the calc-mica-schist, as the crest rises again, seems to rest for a short distance on this rock.[3] But the quartz-schist soon reappears at the base of the Diablons (11,850′), in its usual position, and thence descends towards the valley, disappearing at last beneath talus at some height above Zinal. On the western side of the Val d'Anniviers the quartz-schist, in a like position, runs southward from the Becs de Bosson, sweeps round the head of the Val de Moiry (a tributary of the main valley), passes along the flanks of the Corne de Sorebois (9,207′)—where it is capped by a fair thickness of the calc-mica-schist (very micaceous)—and then descends, reaching the bed of the valley opposite to Zinal, where it is well exposed. These facts seem to me explicable only on the hypothesis that the *Casanna Schiefer*, the quartz-schist and the calc-mica-schist, with the associated *Grüner Schiefer*, form part of a huge fold, the axis of which slopes up towards the north at a moderate angle. This, at first sight,

[1] It is called *Glanz Schiefer* (*schistes lustrés*) on *Blatt* xvii, and *Graue Schiefer, kalkhaltig*, on *Blatt* xxii. On the former its place in the table of colours seems to make it newer than the Carboniferous, but on the latter it is the older rock. So far as regards the calcareous and micaceous schists which are associated with the quartz-schist, I have no doubt that the whole group is pre-Carboniferous; but the other map appears to me to designate by the same tint two rocks which differ in locality, lithological characters, and geological age.

[2] I intended to make an exact measurement as I came down the valley, but was hurried by the on-coming of a heavy shower.

[3] I have not examined this part, so cannot say whether the quartz-schist is absent or the outcrop is too thin to be indicated on the map.

appears to warrant the identification of the Pontiskalk with the calc-mica-schist. But even a brief examination of the slopes on which the former rock occurs shows us that we are dealing with a very complicated piece of geology, and I have little doubt that the Pontiskalk is a much newer rock than the calc-mica-schist and its associates. But to give my reasons for this opinion—and these are not of an *à priori* character—would extend this paper to an unreasonable length.

The quartz-schist certainly varies considerably in thickness. But I made no measurements, for in a district like the Alps their value must often be uncertain, and this point had no bearing on the questions with which I was concerned. In places I think it exceeds a hundred feet. It also varies in character. It is distinctly pebbly near Fang, to the ESE. of the Weisshorn Hotel (*i.e.* under the Tounot), and on the left bank of the valley opposite to Zinal (though here the pebbles are generally small). It is often rather coarse and slightly "gneissose" in texture, owing to the presence of a filmy, pale-green mineral, but from this condition it passes into a nearly homogeneous, white rock,—as in places opposite to Zinal, and at the Alpe de Collier (on the right bank, about 1500 feet above the village). As a rule, the quartz-schist is not only less slabby than it is above Saas Fee (though that structure may be observed near the alp just named), but also (so far as I have seen) it wants that occasional distinct banding with a grey mica. The most pebbly part—where we examined it *in sitû* south of Fang —was some four feet thick. The pebbles were in layers, the thickest of these being about fifteen inches, but they were not restricted either to the bands or to this part of the rock. They generally varied from well-rounded to subangular, and often seemed slightly distorted by pressure. Most of them were white vein-quartz, but I also noticed a reddish quartz (small), and a compact light-green rock, rather soft and flatter in shape, which sometimes seemed to merge into the films already mentioned.

In addition to the specimen from near the Weisshorn Hotel, I have examined microscopic sections from the following localities: Fallen pebbly blocks north of Fang; pebbly band *in sitû* south of Fang; slabby, slightly fissile quartz-schist near Alpe de Collier; rather pebbly rock opposite to Zinal; most compact and white variety, in same mass. I may refer to my former paper for a general account of the microscopic structure of the quartz-schist, and content myself with calling attention to any differences exhibited by these specimens. In most of them the constituents vary much more in size than in those from Saas Fee, but the "matrix" in which the larger fragments are set is more fine-grained. The most uniform in character, as might be expected, are the examples from the Alpe de Collier and from opposite to Zinal (compact variety). The former consists usually of quartz granules rather less than ·0025″ in diameter, and of mica flakelets, which seldom attain ·025″ in length. But even here the matrix becomes a little coarser in places, the quartz-grains occasionally

ranging up to ·02″; while the second specimen is throughout rather coarser, the quartz-grains in it attaining about double the last-mentioned size. All the other slices exhibit great variety in structure, the matrix being sometimes quite as fine as in the first instance, but generally more micaceous. The included fragments are mostly quartz, and their exterior (and this is also true of the granules) is "ragged" in outline, except in certain cases, when it is surrounded by a kind of envelope of mica, like a pellet wrapped in paper. Of these fragments the smaller are generally simple, the larger composite, being apparently vein-quartz, though one or two of them resemble a rather minute and highly altered quartzite. The others often exhibit strain shadows, are sometimes cracked (occasionally with slight displacement), and are again cemented with chalcedonic quartz. But there are cases where this material seems as if it had been the result of molecular change, without fracture, along a certain direction in the grain; and when it occurs at the exterior, as it not seldom does, it appears to have been formed by the same process rather than by accretion. Felspar is always present, though generally rather altered; cleavage may be observed, but I have not come across polysynthetic twinning. No doubt it represents original fragments, though at the present time it is not obviously clastic. Some of the felspar-grains may be seen to pass into a mass of minute mica, cemented by exceedingly fine chalcedonic quartz, and I think that the micaceous part of the matrix has been formed generally by the alteration of clayey or silty matter. The mica exhibits a very faint tinge of a greenish colour, and is probably not materially different from that in the Saas Fee rock. It occurs in fairly regular flakelets, and in most cases is clearly authigenous, though a few larger flakes possibly may be derivative; that is probably true of two or three bits of rather altered biotite. As in the other rock, I note occasionally small zircons, rutiles, and epidote or zoisite, with iron oxides and some brownish granules, which I think are garnets, though one or two suggest the possibility of idocrase; but quartz and mica (almost colourless), with some felspar, are the dominant constituents. One fragment may represent a very fine-grained micaceous schist. This, I suspect, belongs to the compact greenish rock mentioned above, of which, however, I failed to obtain a good piece in a position favourable for a section.

These specimens from the Val d'Anniviers present more resemblance to the crushed Torridon Sandstone and the "piped" quartzite mentioned in my last paper, than do those from Saas Fee, but they are by no means identical with either. They have been affected by pressure, but the mineral change is much more complete than in Scotch rocks, and there is nothing to show that this pressure was the chief agent in producing the metamorphism. They retain, probably owing to their greater coarseness and more heterogeneous character, much more distinct traces of their original condition than the quartz-schists from Saas Fee, but their differences from fragmental rocks in the Mesozoic or later Palæozoic systems in the

Alps, to my mind, increase the probability that they, and the calc-schists and mica-schists associated with them, are much more ancient than any of these—in other words, that they very probably belong to the Archæan era.

IV.—Notes on the Whitehaven Sandstone.

By T. V. Holmes, F.G.S.

IT is not surprising that the earlier geological writers on the district north and west of the Silurian and other hills of Lakeland, and between the River Caldew and the Solway, should have arrived at diverse conclusions as to the affinities of certain sandstones and shales of reddish or purple-grey tint, which are now known to occur at various horizons in the Carboniferous series. For this district presents unusual difficulties to an understanding of the disposition of the rocks beneath the Glacial Drift.

In the belt of country nearest Lakeland, occupied by the Carboniferous Limestone series, which is mostly from about 400 feet to more than 1000 feet above the level of the sea, the various beds of limestone and sandstone are frequently traceable for a certain distance, and the presence here and there of a considerable thickness of Glacial Drift obscures, but does not wholly hide, the arrangement of the older rocks. But the obscurity greatly increases as we descend into the lower ground towards the Solway, in which the Upper Carboniferous, the Permian-Triassic,[1] and the Liassic rocks exist, for there the surface consists almost entirely of Glacial Drift and other superficial beds. Here and there, often at rare intervals, Carboniferous and Permian-Triassic beds may be seen in the banks of the rivers and streams, or as small patches elsewhere; but they make no definite features; the surface-ridges are composed wholly of Glacial Drift. And when, after long and laborious work in the field, approximate boundaries between the older formations can be made out, they are usually lines of fault. Coast sections, also, are few and far between. From a point about two miles north of Maryport to the mouth of the Eden at Rockcliff superficial beds only can be seen. Permian-Triassic (St. Bees) Sandstone appears at Maryport, but southward, between Maryport and Whitehaven, coast-sections in the older rocks are rare, though there is a continuous series of them from Whitehaven round the headland of St. Bees.

Then, in addition to the difficulties arising from the covering of Glacial Drift, we have (along the Carboniferous and Permian-Triassic junction from Maryport north-eastward) another in the reddish or purple-grey tint of many of the Carboniferous beds, which approximates so closely to that of the Permian-Triassic deposits as to make the task of distinguishing between them one of greater difficulty than usual. I may add, however, that when engaged on the Geological Survey in North Cumberland many years

[1] I use this term to include all the red rocks between the Coal-measures and the Lias.

ago, my colleagues and I had gradually learned from experience, that where junctions between these formations occurred, the reddish or purple-grey Carboniferous tints were always distinguishable from the more brick-red colour of the other series. On the other hand, it was found that there was no hue distinctive of any particular Carboniferous horizon, and that the position in the series of highly-coloured Carboniferous rocks in any locality could be learned only from the careful study of that and adjacent districts.[1]

In the cliffs on each side of the harbour at Whitehaven there is a mass of purple-grey rock, mainly sandstone, which lies with a certain amount of unconformity on the beds beneath. This appearance of unconformity, visible to every geological visitor, has necessarily excited much attention, and the affinities of the Whitehaven Sandstone, as it has been called for more than half a century, have been much discussed. For as it differs in colour from the beds on which it rests, and is also somewhat unconformable to them, it was by the earlier writers generally classed with the Permian-Triassic rather than the Carboniferous rocks. For example, I may mention that the late Matthias Dunn, in a paper on the Coalfields of Cumberland, published in vol. viii, Trans. North Eng. Inst. Min. Engineers (1859–60), calls it the "Lower Red Sandstone," to distinguish it from the Upper Red (or St. Bees) Sandstone, and remarks that they are usually divided by a bed of magnesian limestone. And as a result of looking at this and other rocks of similar colour as Permian he shows in the map illustrating his paper, Permian-Triassic rocks spreading eastward of Aspatria as far southward as the source of Shalk Beck, and about a mile north of the junction of the Caldbeck with the Caldew. A large area, widening eastward from Aspatria till it attains a breadth of more than three miles at Shalk Beck and the Cardew, was thus once classed as Permian-Triassic, which is now admitted to be Carboniferous.[2]

At the present day, however, there is no dispute as to which of the two formations just mentioned the Whitehaven Stone belongs. Such differences of opinion as now exist are as to whether Mr. J. D. Kendall has or has not satisfactorily identified as Whitehaven Sandstone certain rocks at various places in and beyond the limits of the West Cumberland Coalfield. Mr. Kendall, who has written much on this subject during the past fifteen years, thus describes the Whitehaven Sandstone in his latest paper, which was read before North of Eng. Inst. Min. and Mech. Engineers in October, 1895, and has since been published in the Trans. Fed. Inst. Min. Engineers. His opening paragraph is as follows:—

[1] My own experience in various parts of North Cumberland is given in a short paper "On the distinctive colours of the Carboniferous and Permian or Triassic (Poikilitic) Rocks of North Cumberland": Trans. Cumb. Assoc., part vii (1881–2), p. 79.

[2] Having spoken of the sandstone at Rosegill, near Bullgill railway-station, as "Whitehaven Sandstone" in the paper on the distinctive colours of the Carboniferous and Permian-Triassic rocks already mentioned, it may be well to say that I did so on Dunn's authority, not as the result of my own investigations.

"In the cliffs along the coast near Whitehaven, occurring interruptedly over the prolific Coal-measures, there is a purple-grey arenaceous rock known to geologists as the Whitehaven Sandstone. It is there, at least, 170 feet thick. The same rock, or rock of the same general character, also occurs over other parts of the coalfield, being sometimes interbedded to a considerable extent with shale, and attaining then an aggregate thickness of 500 or 600 ft. It is therefore convenient to include the whole of these rocks under the name of the 'Whitehaven Sandstone Series.'"

A little farther on are the following additional remarks on its composition:—

"It will be seen from these sections (Appendix A) that the Whitehaven Sandstone Series consists almost entirely of sandstone and shale, of a red, grey, or brown colour, as described in the sections, but the writer prefers to call it purple-grey. With these beds are intercalated, in the lower part of the series, rocks of the ordinary Coal-measure colour and a few thin coal-seams. Two thin beds of *Spirorbis* limestone have been met with in the series at Frizington Hall, and occasionally, in different parts of the district, inconstant beds of conglomerate appear, as in section No. 3. In the neighbourhood of Flimby and Maryport, the base of the series is formed by a thick sandstone, as seen in section No. 6. At Whitehaven, Cleator Moor, and Frizington, the base-rock is variable, being in some places argillaceous, in others arenaceous."

Mr. Kendall remarks that in 1883 he published a paper on "The Structure of the Cumberland Coalfield," which "for the first time dealt with the Whitehaven Sandstone Series over the whole field, showing it to be unconformable Upper Coal-measures." His object in his paper of last year is to reply to the objections of critics of his views with regard to the Whitehaven Sandstone, as expressed in his paper of 1883, and to reassert them with additional details. Incidentally, he considers the hypothesis that the purple-grey Carboniferous rocks owe their colour to Permian staining, and thinks that the evidence is against it, and that the colour is pre-Permian.

It is obvious that a formation so variable in thickness and composition as this "Whitehaven Sandstone Series" is (according to Mr. Kendall) very difficult to identify far from Whitehaven, unless its colour is almost unique, and its outcrop traceable across the country so that its unconformity to the other Carboniferous strata is thereby made manifest. But the unconformity would be shown in colliery workings, should the unconformable beds cross a coalfield in which they cannot be traced, because the surface beds consist of Glacial Drift, as in the present case.

In my paper, lately referred to, on the distinctive colours of the Carboniferous and Permian formations of Cumberland, I mentioned the Whitehaven Sandstone as occupying a position in West Cumberland analogous to that of the Red Rock of Rotherham in the Coalfield of Yorkshire. Having worked a good deal in the district about Rotherham when engaged on the Geological Survey in that Coalfield, I am enabled to give the following particulars about the Red

Rock. It was found to occupy an area of about ten miles in length and usually from one to two miles in breadth. It could be traced from place to place, and its relations to the ordinary conformable measures be thereby demonstrated. Its red colour made it almost unique in the district in that respect, and its lithological variations from place to place were slight and unimportant.

In Cumberland, as I have already stated, the outcrops of the harder rocks of the Coal-measures are not traceable, owing to the thick surface-covering of Glacial Drift. On the other hand, no aid from colliery workings was obtainable in the case of the Red Rock of Rotherham, which throughout its course remained geologically far above the horizons in which collieries then existed. But the Whitehaven Sandstone—according to Mr. Kendall—has an unconformity of much greater magnitude, and may be recognized from Whitehaven, at the south-west, across the whole area of the Coalfield to and beyond its north-eastern boundary. For on Lower Carboniferous ground, about 30 miles north-east from Whitehaven, the Whitehaven Sandstone is still recognized by Mr. Kendall in the 700 or 800 ft. of reddish or purple-grey sandstone and shale seen in Shalk[1] Beck at and near Nine Gills!

It is obvious that the only evidence which could demonstrate the truth of this view, that the Whitehaven Sandstone is to be recognized at various spots from Whitehaven to Shalk Beck, is that which might be obtainable from colliery workings. Fortunately the course taken by the Whitehaven Sandstone is—according to Mr. Kendall—along the whole length of the Coalfield. This would be a singular and somewhat improbable thing in itself, for, from Maryport eastward, the uppermost beds of the Coal-measures must have been very largely cut off by the long lines of fault which bring in the St. Bees Sandstone. Still, the evidence of a long chain of collieries, each showing *unconformable* masses of purple-grey rocks, might enable us to trace the Whitehaven Sandstone from one end of the Coalfield to the other, and show that, though lithologically variable, it yet formed a real unconformable series. But Mr. Kendall never appeals to evidence of *unconformity* at the base of the purple-grey rocks which he recognizes as Whitehaven Sandstone in colliery sections. And any other evidence for the purpose of showing that certain purple-grey rocks belong to the unconformable Whitehaven Sandstone series is manifestly worthless, unless it can be shown that both in lithological character and in colour the Whitehaven Sandstone series is unique. But where it can be seen at Whitehaven it presents no special and distinguishing lithological peculiarities, nor has it any fossils of a special kind. The interest attaching to it arises solely from its apparent unconformity to the beds on which it rests. As to its colour—rocks of a reddish or purple-grey tint may be seen in North Cumberland on Carboniferous horizons of every age, on the Esk, Line, Carwinley Burn, Hether Burn, and other Border streams, as well as in the Caldew, Shalk

[1] Shalk is sometimes written *Chalk* or *Shawk*.

Beck, and other rivers of West Cumberland. Again, the absence of coals of any thickness above a certain horizon in the Coal-measures gives no presumption whatever tending to show the presence of *unconformable* Whitehaven Sandstone. On certain horizons in coalfields it is usual to find few and thin coals, while 500 feet above or below they may become thick and numerous. In other words, it is usual to find alternations of conditions tending at one time mainly to the deposition of sandstones and sandy shales, at another of more clayey shales and of coals. Yet Mr. Kendall identifies as Whitehaven Sandstone measures distinguished only by purple-grey colour and absence of thick coals.

Towards the conclusion of his paper, Mr. Kendall remarks that: "In the area lying immediately to the north-east of the Coalfield, he [Mr. Holmes] has coloured as belonging to the Millstone Grit and Carboniferous Limestone series, rocks which also belong to the Whitehaven Sandstone series or Upper Coal-measures."

It will be noticed that Mr. Kendall admits that the area in question is "north-east of the Coalfield," or, in other words, that Lower Carboniferous rocks might naturally be expected there. When working in that district I found in Shalk Beck an unusually good series of sections, the beds consisting of sandstones and shales of a reddish or purple-grey colour, with a high but variable dip of from 15 to 60 degrees, and attaining a thickness of at least 700 to 800 feet. The direction of their dip was perfectly normal, looking at them as Lower Carboniferous beds; and in lithological character and in colour they resembled the Lower Carboniferous sandstones and shales that I had been familiar with in the district generally and in other localities. In short, I maintain that there are no grounds whatever for supposing them to be other than ordinary Lower Carboniferous sandstones and shales, such as would naturally be expected there. Yet Mr. Kendall, without a single scrap of real evidence in support of his view, asks us to consider these Shalk Beck beds as the "Whitehaven Sandstone Series," which has expanded from a thickness of 170 feet at Whitehaven to one of 700 to 800 feet thirty miles away! It seems to me that to admit so gigantic an assumption to be a bare possibility, is to make a very handsome concession to Mr. Kendall. And as the *onus probandi* falls upon his shoulders, I do not envy him the task of proving his case.

It may be worth while mentioning here, that in 1883, Mr. Kendall published a paper on "The Structure of the Cumberland Coalfield" (Trans. N.E. Inst., vol. xxxii, p. 319, and vol. xxxiii, p. 121), maintaining the general conclusions arrived at in his latest contribution to the subject. In a short paper entitled "Notes on the best locality for Coal beneath the Permian Rocks of North-west Cumberland" (Trans. Cumb. and West. Assoc. 1883–4), I commented briefly, *inter alia*, on Mr. Kendall's views as regards the Whitehaven Sandstone, pointing out the necessity of complete evidence of unconformity, and also that the sheet of sections illustrating Mr. Kendall's paper appeared to me to contradict his views. Some remarks in reply, by Mr. Kendall, appear in Trans. Cumb. and

West. Assoc. 1884–5, and a rejoinder by myself in Trans. Cumb. and West Assoc. 1885–6.

In 1891, a paper by Mr. William Brockbank, F.G.S., "On the Occurrence of the Permians, *Spirorbis* Limestones, and Upper Coal-measures at Frizington Hall, in the Whitehaven District," was read, and has since been published in vol. iv (fourth series), Mem. and Proc. Manchester Lit. and Phil. Soc. Frizington Hall is about three miles east of Whitehaven. The paper consists of the details of a boring made at Frizington Hall by the Vivian Boring Company in 1890–1. The Whitehaven Sandstone was pierced in this boring, and its details are of so much interest that I here give an abstract of it from Mr. Brockbank's paper.

Abstract of the Frizington Hall Section.

	Thickness. ft.	in.	Depth. ft.	in.
Surface clays	22	0	22	0
Permian breccia	20	0	42	0
Shales, chiefly red, with purple sandstone	69	1	111	1
Spirorbis limestone (reddish)	3	9	114	10
Purple sandy shales	10	8	125	6
Conglomerate	11	0	136	6
Grey and pink mottled shaly sandstones	6	0	142	6
Shaly conglomerate	39	1	181	7
Red and grey sandstone and shale	80	11	262	6
Spirorbis limestone	1	0	263	6
Shales and marls, variously coloured (sandstone 1 ft. 6 in.)	33	10	297	4
Brassey coal	0	4	297	8
Blue metal, with sandstone, 1 ft.	18	5	316	1
Coal	1	0	317	1
Metal, chiefly blue, marl and fireclay	88	11	406	0
Coal	1	3	407	3
Blue metal	10	8	417	11
Red or reddish sandstone and shale	42	9	460	8
Red and purple sandstone and shale	69	10	530	6
Conglomerate	11	10	542	4
Reddish-grey sandstone and shale	30	11	573	3

Boring ended.

Mr. Brockbank remarks that the three coals are in true Upper Coal-measures, and that he considers the rocks from a depth of 460 ft. 8 in. to the bottom of the boring to be the sandstones seen on the coast at Whitehaven, which they strongly resemble. He adds, that if he be correct in his identification, "they thus become Middle Coal-measure sandstones beyond doubt, as they are 214 feet under the lowest *Spirorbis* limestone." And he also states tha though the Whitehaven Sandstone is to be seen for a considerable distance on the coast where the strata above it have been denuded away, he believes this is the first time it has been recorded where its true position in the Coal-measures is shown. Mr. Kendall, on the other hand, claims the whole of the beds below the Permian as belonging to the "Whitehaven Sandstone Series." And to Mr. Brockbank's remark that the Whitehaven sandstones "thus become Middle Coal-measure sandstones beyond doubt, as they are 214 feet

under the lowest *Spirorbis* limestone," Mr. Kendall simply replies—"But surely mere thickness of strata cannot, of itself, determine geological level."

It is to be regretted that the boring did not go deep enough to show us the nature of the rocks on which the Whitehaven Sandstone rests at Frizington Hall, so as to enable us to note the resemblances and differences in that respect between that place and the cliffs of Whitehaven, and possibly obtain information as to an increase or decrease of the unconformity eastward. A point of interest in the Frizington Hall boring appears to me to be the way in which the section is divided into zones. These consist of an upper one, mainly sandy, between the *Spirorbis* limestones; a middle one, in which shales, fireclay, and coals greatly predominate; and a lower, in which sandy conditions again prevail. And we may also note that in the upper sandy zone the colour is mostly reddish or reddish grey; in the middle, or shaly zone, the metals and shales are mainly blue; while, in the lower sandy zone, red and reddish-grey tints again appear almost exclusively.

I have already remarked that reddish or purple-grey Carboniferous rocks may be seen in North Cumberland on every horizon in that series. And this Frizington Hall section seems to me to point to the probable explanation of this fact, and also to explain why rocks so tinted are almost invariably either sandstones or sandy shales. It certainly gives a very strong support to a theory as to the origin of the purple-grey colour of these Carboniferous beds which I must confess to have looked at, till lately, with some distrust; I mean the theory that the purple-grey rocks have been stained by the red Permian-Triassic strata which once wholly covered them, though now so large an area of Carboniferous rock lies bare. The Permian-Triassic beds are highly unconformable to the Carboniferous, and rest here on lower, there on higher, members of the older series. Should, then, the older rocks owe their colour to the newer formations once resting upon them, it is obvious that we may expect to find that the lower as well as the higher Carboniferous beds have been stained. We may also expect to find that the rocks are stained or left unstained mainly in proportion to their permeability or impermeability. In other words, we should expect to see what we do actually see in this Frizington Hall section, sandy zones coloured purple-grey and a clayey zone uncoloured. And this is what we may expect elsewhere. Coal-seams are not likely to be found in purple-grey rocks, because coals are—as in the Frizington section—usually found with clayey, impermeable shales which are not likely to be stained. This section, too, is alone sufficient to refute the notion that there is any necessary connection between purple-grey colour and a certain Carboniferous horizon.

Another conclusion suggested by this Frizington section is that as the Whitehaven Sandstone, though not low down in the Coal-measures, occupies by no means the highest place, its unconformity, if considerable, is much more likely to have been noted (did it exist) in colliery workings, than would have been the case with

a bed in the uppermost strata. That the unconformity has not been noted, only adds to the strong presumption that there is none to note, and that instead of increasing in magnitude from Whitehaven north-eastward to Shalk Beck it does just the reverse.

Indeed, it is time that we recognized that the magnitude of this unconformity, so certain to be noted by all geologists because conspicuous in a sea-cliff and accompanied by a change of colour, in a country where natural sections are so few, may have been immensely exaggerated. The Cumberland Coalfield is small and drift-covered, and it is impossible from observations in the field to learn much about the characteristics of its various beds. Even the railway cuttings generally show nothing but Glacial Drift. But if we turn to the Geological Survey Memoir on the Yorkshire Coalfield, a district practically free from Glacial Drift, we learn from Prof. Green's remarks in chap. ii much which illustrates the fact that the circumstances under which the Coal-measures were deposited were such as frequently to produce appearances of unconformity which are really mere local erosions. He notices, p. 14, that the sandstones are great wedge-shaped banks which sometimes, from a thickness of 100 ft., wedge out to nothing in a space of half a mile or less; that they are equally inconstant in composition or grain, a coarse, irregularly-bedded grit passing into a fine-grained, laminated sandstone, etc.; and remarks that these facts are easily explained if we suppose the sandstones "to have been deposited on an uneven floor, in shallow water traversed by numerous and opposing currents. Their wedge-shaped form may be sometimes due to their being banks piled up by currents running now from one and now from the opposite quarter, and may be sometimes caused by depressions in the bottom of the water having been filled in with sand."

Then we read on p. 24—"The junction of a sandstone with the overlying shale is often very uneven, as if part of the original sand-bank had been cut away before the sand began to be deposited. In many cases, too, the top of a sandstone is furrowed by branching channels, such as would be cut out by a system of little rivulets. In such a case there can be little doubt that the surface of the sandstone bed was for a time a land surface traversed by streams of running water."

The general conditions under which the Coal-measures of West Cumberland were deposited were evidently identical with those prevailing during the Coal-measure period in Yorkshire, and would tend to produce similar results in each district. It seems, therefore, useful to remind those interested in this question both that the lithological character of Coal-measure sandstones is extremely liable to vary, and also that appearances of unconformity in Coal-measures are peculiarly liable to be deceptive. In the discussion which followed the reading of a paper by Mr. Kendall "On the Whitehaven Sandstone Series" at the Geological Society, on February 20, 1895, Mr. Strahan, of the Geological Survey, inclined to think that the appearances in the Whitehaven cliffs indicated simply local erosion, not unconformity of the least importance. He also thought the

purple-grey colour due to staining. My own remarks were to the effect that Mr. Kendall's views could be established only by the evidence of colliery workings, and that no such evidence was forthcoming. Mr. Marr confirmed the existence of rocks of various ages around the Lake District which had been stained red. There were no other speakers. A brief abstract of Mr. Kendall's paper is given. So far as my memory serves it was practically identical with his latest contribution to the subject. See Quart. Journ. Geol. Soc., vol. li, part 2 (May, 1895), p. 235.

I would simply say, in conclusion, that the only evidence we have about the position among the Coal-measures of the Whitehaven Sandstone is that furnished by the Frizington Hall boring. That, as to whether the appearance of unconformity in the cliffs of Whitehaven indicates an unconformity of any magnitude or merely local erosion of no importance whatever, we have no direct evidence. But that from the frequency of cases of mere local erosion in Coal-measures, combined with the absence of evidence of any unconformable series in colliery workings, it seems most probable that the unconformity is but slight and local. That the purple-grey colour of Carboniferous beds on every horizon is due to staining, which has affected the more or less permeable strata and left the impermeable unstained. Consequently the presence of a belt of purple-grey sandstones and sandy shales, above an unstained belt of clayey shales and coals, is simply evidence of the coming in of sandy conditions and the cessation of clayey ones. Finally I would remark, that when the existence of a great unconformity at the base of the Whitehaven Sandstone, increasing north-eastward, is proved by the evidence of colliery workings, it will be time to consider whether the classification of the purple-grey beds of Shalk Beck needs revision. At present it appears to me that Mr. Kendall's views as to this unconformity and its effects are unsupported by any real evidence, and have no legitimate claim to consideration. It is for him to show that what seem now to be merely needless and baseless assumptions are founded upon solid grounds.[1]

V.—On *Goniatites evolutus*, Phillips, and *Nautilus tetragonus*, Phillips; with a list of the Species belonging to the genus *Subclymenia*.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

In 1836, Prof. J. Phillips[2] described and figured from the Carboniferous Limestone, *Goniatites evolutus*, and for this species D'Orbigny,[3] in 1850, instituted the genus *Subclymenia*.

In 1851, L.-G. de Koninck[4] described and figured his species *Nautilus Omalianus*, from the Lower Carboniferous Limestone of Visé, Belgium, and gave no synonymy. In 1880, the same author[5]

[1] It may prevent possible misunderstanding to state that the foregoing remarks express simply my own personal views.

[2] "Geol. Yorkshire," pt. ii, 1836, p. 237, pl. xx, figs. 65–68.

[3] "Prod. de Paléont.," vol. i, 1850, p. 114.

[4] "Animaux Fossiles," Suppl., p. 711, pl. lx, figs. 3*a–d*.

[5] "Faune Calc. Carb. de la Belgique," pt. ii, p. 83, pl. xlv, figs. 5, 6: Ann. Mus. Roy. d'Hist. nat. de Belgique, sér. Paléont., vol. v.

figured two Belgian specimens which he referred to Phillips' *evolutus*. He adopted D'Orbigny's generic designation, and united with this species his previously described *Nautilus Omalianus*. Whilst recognizing their generic affinity, Prof. Hyatt[1] appears to consider the examples referred by De Koninck to *evolutus* to be specifically distinct from Phillips' species, and for the Belgian form proposes the name *S. gibbosa*. He also considers *Nautilus Omalianus* to be specifically, though not generically, distinct from both.

In 1836, Prof. Phillips[2] also described and figured from the Carboniferous Limestone the species *Nautilus tetragonus*, which in 1854 Prof. Morris[3] referred to M'Coy's *Discites*,[4] regarding the latter as a subgenus of *Nautilus*.

Foord,[5] in 1891, considered *Nautilus tetragonus*, Phillips, and *Nautilus Omalianus*, De Koninck, to be identical; and, referring the species to M'Coy's *Discites*, accepted De Koninck's specific name, remarking that "according to the strict letter of the law of priority, Phillips' name should be adopted for this species, but his description and figures are so defective that it would be quite impossible to recognize the fossil thereby."

Phillips described his *Goniatites evolutus* as follows: "Volutions apparent, their section round in young, oblong in old whorls; septa with a deep, acute, dorsal sinus, and obtuse-angled first lateral lobe," giving as the locality "Flasby, etc." Of the specimens which he figured, the original of figs. 66, 67, and 68, is in the York Museum.[6] The writer is greatly indebted to the authorities of that Museum for the loan of the specimen; it is only the internal cast of four loculi, but a careful examination of the fossil has enabled him to identify with Phillips' species a splendidly preserved example, now in the Gilbertson collection in the British Museum.[7]

Of *Nautilus tetragonus*, Phillips gave the following description: "Flat, discoidal, whorls tetragonal, back slightly concave, with a small spiral ridge within the angles; striæ bent, sharp, rising into plaits on the edges; septa concave outwardly; (oblique undulations on the sides of the cast). *Var.* β, inner edges rounded"; and he mentioned as localities "Kulkeagh; Bolland; Northumberland." The description is accompanied by figures of at least three specimens, one of which (pl. xvii, figs. 26, 27) is, however, doubtfully referred to this species.[8] The writer has been able to examine only one of

[1] A. Hyatt, "Carboniferous Cephalopods," Second Paper: 4th Ann. Rep. Geol. Surv. Texas, 1892 (1893), p. 414.

[2] *Op. cit.*, pt. ii, 1836, p. 233, pl. xxii, figs. 33, 34; pl. xvii, fig. 24 (26? 27? in explanation of plate on p. 250).

[3] "Cat. Brit. Foss.," 2nd ed., 1854, p. 309.

[4] F. M'Coy, "Synop. Carb. Foss. Ireland," 1844, p. 17.

[5] "Cat. Foss. Ceph. British Museum," pt. ii, 1891, p. 87.

[6] H. M. Platnauer, "List of Figured Specimens in York Museum": Ann. Rep. Yorks. Philos. Soc. 1890, p. 79. The locality there given ("Flaxby") is an error; Mr. Platnauer informs me that it should have been "Flasby."

[7] B.M. No. C. 5336.

[8] A specimen in the Gilbertson collection in the British Museum (No. C. 237*c*) is believed to be this figured example. It is but a fragment, and greatly resembles "*Nautilus subsulcatus*," Phillips (= *Cœlonautilus subsulcatus*). It certainly does

the other two specimens, viz. the original of pl. xvii, fig. 24, which is in the Gilbertson collection in the British Museum (No. C. 222); but Phillips' description seems to have been based chiefly upon the specimen represented in pl. xvii, figs. 33, 34, for fig. 33 represents the "back slightly concave, with a small spiral ridge within the angles," and in fig. 34 are depicted the "bent, sharp striæ, rising into plaits on the edges." Both these characters are to be seen in well-preserved specimens of *Cœlonautilus quadratus* (Fleming)[1]; and further, the section indicated in fig. 33, as well as the form of the septa given in fig. 34, agree so well with these characters in Fleming's species, that in all probability the fossil here figured is referable to this species; but a definite opinion cannot be given without an examination of the specimen. These characters, however, are not present in the specimen figured by Phillips, pl. xvii, fig. 24, which has the test well preserved; the transverse striæ are not nearly so much bent on the lateral area as in *Cœlonautilus quadratus*, and further, over about half of the width of the lateral area, and for more than one-half of the length of the fragment figured, the transverse striæ are thickened at regular intervals, so that they have the appearance of being crossed by spiral lines. The sculpture, in fact, is that of Phillips' "*Goniatites*" *evolutus*, as exhibited by the specimen to be referred to later on. The peripheral lobe of the suture-line also agrees with that of the same species.

Again, the periphery in *Cœlonautilus quadratus* bears a strong ridge at about one-quarter of the width of the peripheral area from each angular margin, and in well-preserved specimens there is sometimes a much more feeble ridge about half-way between each of these strong ridges and the angular margin; the transverse striæ are also very feeble. But in the specimen depicted by Phillips as *Nautilus tetragonus* in pl. xvii, fig. 24 (probably Phillips' *var.* β), the periphery bears near each margin about six longitudinal lines, which diminish in strength from the angular margin inwards; and the transverse striæ are much more pronounced, an ornamentation agreeing with that of Phillips' "*Goniatites*" *evolutus*, as exhibited by the specimen described below.

We conclude, then, that Phillips' *Nautilus tetragonus* is in part, and only in part, referable to that author's "*Goniatites*" *evolutus*.

Upon this latter species, as has already been stated, D'Orbigny in 1850 founded the genus *Subclymenia*; still, several subsequent writers[2] have regarded the species as a Goniatite. Although not a Goniatite, but a Nautiloid, the genus (*Subclymenia*) to which it is referred is

not agree with the specimen figured by Phillips in pl. xvii, fig. 24. The figure differs in some respects from the specimen. The periphero-lateral angles should have been represented more obtuse, and the suture-line with a narrower and shallower sinus on the periphery.

[1] *Nautilus quadratus*, J. Fleming, "Hist. Brit. Anim.," 1828, p. 231.

[2] J. Morris, "Cat. Brit. Foss.," 2nd ed., 1854, p. 303; G. Sharman and E. T. Newton, "Geol. N. Derbyshire," 2nd ed., 1887, Appendix 1, p. 182: Mem. Geol. Surv.; R. Etheridge, "Brit. Foss.," vol. i, Palæozoic, 1888, p. 311; G. H. Morton, Proc. Liverpool Nat. Field Club for 1894, p. 23, 1895.

regarded by Hyatt[1] as the highest type of Nautiloidea, since with its "ventral V-shaped lobe and ventral siphon" it is "so like *Goniatites* that it can be separated only by its young and the gradations of forms which connect it with certain well-known Nautiloids."

The original of Phillips' fig. 66 is simply an internal cast of four loculi; there is no trace of the test. It has the following dimensions:—

	mm.
Length	48
Height of whorl at anterior end	22
Greatest thickness ,, ,, ...	19
Width of periphery ,, ,, ... about	12
Height of whorl at posterior end ...	16·5
Greatest thickness ,, ,, ...	15
Width of periphery ,, ,, about	9

The greatest thickness of the whorl is at about one-third of the height of the whorl from its inner edge. The periphery is flattened, and has no central channel such as Phillips represents in fig. 67; the siphuncle is well below the surface, its centre at the anterior end of the specimen being 2·75 mm. from the periphery. The peripheral (or external) saddle of the suture-line is depicted (fig. 68) much too acute; the anterior part of the specimen is here broken a little, causing this saddle to appear more acute than it really was.

A careful comparison with the type has enabled the writer to identify with this species a small but exceedingly well-preserved specimen (see accompanying figures), now in the Gilbertson collection in the British Museum (No. C. 5336), and to characterize Phillips' species more fully than has hitherto been done. It has the following measurements:—

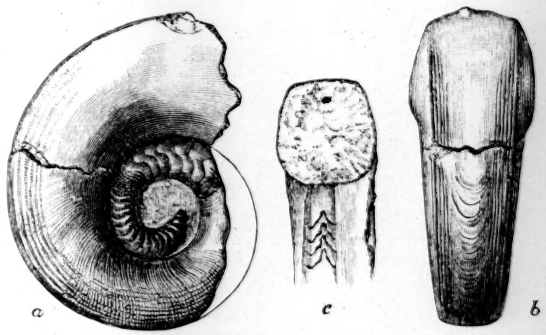
	mm.
Diameter	43
Height of outer whorl	17
Width of umbilicus (suture to suture) ...	15·5
Greatest thickness...	16
Width of periphery	11

The specimen, which is probably not quite complete, consists of nearly two whorls. There is a large central vacuity. The first third of the first whorl is free. The apex has unfortunately been very slightly chipped in clearing the specimen from the matrix. The first chamber is conical, a little more than 1 mm. deep, and with a ventro-dorsal diameter of 1·5 mm. at its anterior end. The free portion is sub-circular in section, but at the completion of the first half whorl the periphery is distinctly flattened and 3·5 mm. wide, the height or ventro-dorsal diameter of the whorl here being 4·5 mm., the greatest thickness being at a short distance from the inner edge. The shell increases rather rapidly, but maintains about the same form of transverse section.

Unfortunately the free portion of the fossil bears only fragments of the test. Near the apex the whorl is crossed by transverse lines

[1] A. Hyatt, "Fossil Cephalopoda in the Museum of Comparative Zoology": Proc. Amer. Assoc. for the advancement of Science, vol. xxxii, 1883, p. 333.

passing from the inner side obliquely backwards to the outer, but on the second third of the first whorl these transverse lines are crossed by longitudinal lines, so that the latter are distinctly crenulated. They cover the lateral area, and increase in strength as they approach the outer portion of the whorl. These ornaments on the lateral area gradually become fainter; at about the middle of the second whorl the transverse lines are much finer, and only a few of the longitudinal lines remain near the periphery, and these are very faint; at the extremity of the specimen only exceedingly fine lines of growth are present.



SUBCLYMENIA EVOLUTA, J. Phillips, sp.

a, lateral aspect; *b*, peripheral aspect; *c*, front view with the outer portion detached, showing the position of the siphuncle and the peripheral lobe of the suture-line as it appears nearly at the end of the first whorl. Carboniferous Limestone: locality unknown.

Drawn from a specimen in the British Museum (Natural History), No. C. 5336. Natural size. (The specimen is quite symmetrical, although it scarcely appears to be so in fig. *c*, owing probably to the piece of matrix adhering to one side of the fossil and covering not only the lateral area of the whorl, but also a narrow portion of the periphery.)

The ornaments on the periphery at the middle of the first whorl consist of about six longitudinal striæ near each margin, diminishing in strength from the angular margin inwards, crossed by exceedingly fine transverse striæ, which in passing from the lateral angles cross the longitudinal striæ obliquely backwards, becoming on the median portion of the periphery more pronounced and forming a wide deep sinus concave forwards. As the shell increases in size, the longitudinal almost obliterate the transverse lines; while the ornaments on the median portion become very distinct, and are also crossed by very fine, obscure, longitudinal striæ. At the extremity of the specimen the longitudinal lines near the margins are more pronounced, and the central curved lines almost obliterated. The central area is slightly raised above the rest of the periphery, and is feebly concave.

The first suture-line is only slightly backwardly curved on the periphery, and the three following suture-lines have merely a very shallow, simply curved, peripheral sinus; but at the middle of the first whorl the suture-line has a distinct V-shaped peripheral lobe, and is on the whole almost similar to that of the adult shell.

The siphuncle is near the periphery, its centre being only 2·75 mm. from the surface, where the whorl is 13 mm. high. Judging from another specimen,[1] the siphuncle was more nearly central in the young shell, *e.g.* where the height of the whorl was only 2·5 mm.

The species may then be characterized as follows:—

Shell discoidal, evolute, rather rapidly increasing, with a large central vacuity; greatest thickness at about one-third of the height distant from the inner edge of the whorl, about three-eighths of the diameter of the shell; height of outer whorl rather more than three-eighths of the diameter of the shell. Whorls at least two; inclusion almost *nil*; umbilicus shallow, wide, nearly three-eighths of the diameter of the shell, its sides sloping and convex. Whorl truncated-oval in section, a little higher than wide, scarcely impressed by the preceding whorl; periphery flattened, the central portion slightly raised above the rest and feebly concave, broad, about two-thirds of the corresponding height of the whorl in width; sides—outer two-thirds flattened, very feebly convex, convergent,[2] the rest strongly convex and continuous with the convex, relatively broad, inner margin. Length of body-chamber not seen. Chambers rather shallow, measured at the middle of the lateral area about three-tenths of the corresponding height of the whorl apart; suture-line with a V-shaped peripheral lobe, nearly as wide as the periphery, a somewhat broader external saddle situated on the periphero-lateral angle, and a single, wide, shallow, lateral sinus, but nearly straight on the inner portion of the whorl, and with a well-marked annular (or internal) lobe. Siphuncle near the periphery, rather small. Test—the lateral area ornamented with fine transverse striæ, crossed by delicately crenulated longitudinal lines, both becoming finer in the adult, the latter losing their crenulations and gradually disappearing first from the inner portion of the sides, and afterwards from near the periphery, leaving in the adult merely fine transverse delicate striæ; the central portion of the periphery with exceedingly delicate backwardly-curved striæ, crossed by very obscure longitudinal lines, much coarser longitudinal lines (about six) occupying a narrow band near each boundary, and diminishing in strength from the angular margin inwards.

Unfortunately the locality of the specimen in the Gilbertson collection, which Phillips figured as *Nautilus tetragonus*, is not quite certain. It is labelled "Northumberland?"

One of Phillips' types of *G. evolutus*, now in the York Museum, came from Flasby, four miles north-west of Skipton, Yorkshire. The species has also been recorded from Chrome Hill, Derbyshire;[3] and from the Poolvash Limestone in the Isle of Man.[4]

Mr. G. H. Morgan, F.G.S., of Liverpool, recorded[5] the species in

[1] From Graig fawr, Prestatyn, Flintshire, and kindly sent to me for examination by Mr. G. H. Morton, F.G.S., Liverpool.

[2] *i.e.* converging towards the plane of symmetry external to the periphery.

[3] G. Sharman and E. T. Newton, "Geol. N. Derbyshire," 2nd ed., 1887, Appendix 1, p. 182: Mem. Geol. Surv.

[4] J. H. Cumming, "Isle of Man," 1848, p. 357.

[5] Proc. Liverpool Nat. Field Club for 1894 (1895), p. 23.

his Presidential Address to the Liverpool Naturalists' Field Club, on "The Recent and Fossil Flora and Fauna of the country around Liverpool," and through his kindness the writer has been able to examine the specimen there referred to. It came from Graig fawr, Prestatyn, Flintshire.

Appended is a list of the species (with synonyms and references) belonging to the genus *Subclymenia*. So far as known, it is confined to the Carboniferous.

SUBCLYMENIA EVOLUTA, J. Phillips, sp.

1836. *Goniatites evolutus*, J. Phillips, "Geol. Yorkshire," pt. ii, p. 237, pl. xx, figs. 65–68. (Flasby, Yorkshire.)
1836. *Nautilus tetragonus* (pars), J. Phillips, *ibid.*, pt. ii, p. 233, pl. xvii, fig. 24 (right and left-hand figures); *not* pl. xxii, figs. 33, 34. (Northumberland ?)
1843. *Goniatites evolutus*, J. Morris, "Cat. Brit. Foss.," p. 179.
1843. *Nautilus tetragonus* (pars), J. Morris, *ibid.*, p. 183.
1848. *Goniatites evolutus*, J. H. Cumming, "Isle of Man," p. 357.
1850. *Subclymenia evoluta*, A. D'Orbigny, "Prod. de Paléont.," vol. i, p. 114.
1854. *Goniatites evolutus*, J. Morris, "Cat. Brit. Foss.," 2nd ed., p. 303.
1854. *Nautilus* (*Discites*) *tetragonus* (pars), J. Morris, *ibid.*, 2nd ed., p. 309.
1883. *Subclymenia evoluta*, A. Hyatt, Proc. Boston Soc. Nat. Hist., vol. xxii, p. 293.
1887. *Goniatites evolutus*, G. Sharman and E. T. Newton, "Geol. N. Derbyshire," 2nd ed., app. 1, p. 182: Mem. Geol. Surv. (Chrome Hill, Derbyshire.)
1888. *Goniatites evolutus*, R. Etheridge, "British Fossils," vol. i, Palæozoic, p. 311.
1891. *Discites Omalianus* (pars), A. H. Foord, "Cat. Foss. Ceph. British Museum," pt. ii, p. 87.
1893. *Subclymenia evoluta*, A. Hyatt, 4th Ann. Rep. Geol. Surv. Texas for 1892, p. 414.
1895. *Goniatites evolutus*, G. H. Morton, Proc. Liverpool Nat. Field Club for 1894, p. 23. (Graig fawr, Prestatyn, Flintshire.)

SUBCLYMENIA GIBBOSA, Hyatt.

1880. *Subclymenia evoluta* (pars), L.-G. de Koninck, "Faune Calc. Carb. de la Belgique," pt. ii, p. 83, pl. xlv, figs. 5, 6: Ann. Mus. Roy. d'Hist. nat. de Belgique, sér Paléont., vol. v (not of Phillips). Calcaire carbonifère (Assise vi): Visé, Belgium.
1893. *Subclymenia gibbosa*, A. Hyatt, 4th Ann. Rep. Geol. Surv. Texas for 1892, p. 414.

SUBCLYMENIA OCCULTA, Hyatt.

1893. *Subclymenia occulta*, A. Hyatt, 4th Ann. Rep. Geol. Surv. Texas for 1892, p. 414. Calcaire carbonifère: Visé, Belgium.

SUBCLYMENIA OMALIANA, De Koninck, sp.

1851. *Nautilus Omalianus*, L.-G. de Koninck, "Descr. Anim. Foss.," Suppl. p. 711, pl. lx, figs. 3*a–d*. Calcaire carbonifère: Visé, Belgium.
1880. *Subclymenia evoluta* (pars), L.-G. de Koninck, "Faune Calc. Carb. de la Belgique," pt. ii, p. 83 (excl. the figures): Ann. Mus. Roy. d'Hist. nat. de Belgique, sér Paléont., vol. v.
1891. *Discites Omalianus* (pars), A. H. Foord, "Cat. Foss. Ceph. Brit. Mus.," pt. ii, p. 87.
1893. *Subclymenia Omaliana*, A. Hyatt, 4th Ann. Rep. Geol. Surv Texas for 1892, p. 416.

SUBCLYMENIA WILLOCKII, Haughton, sp.

1859. *Nautilus Willockii*, S. Haughton, Nat. Hist. Review, vol. vi, p. 507, pl. xxi, figs. 1*a–b*. (Cleenish, Fermanagh, Ireland.)

Although only imperfectly known, this species most probably belongs to *Subclymenia*.

VI.—Notes on Jurassic Ammonites.

By S. S. Buckman, F.G.S.

TWO valuable pamphlets on Jurassic Ammonites have lately appeared. One of these is entitled "Cephalopodes nouveaux ou peu connus des Étages jurassiques de Normandie, par Louis Brasil."[1] This author, who has paid very considerable and successful attention to the Jurassic rocks in the neighbourhood of Caen, describes and figures (there are four plates) nineteen new species of Ammonites belonging to fourteen genera, viz.: *Lytoceras, Phylloceras, Catulloceras, Zurcheria, Dorsetensia, Bajocia, Pœcilomorphus, Hammatoceras, Erycites, Oppelia, Cadomoceras, Strigoceras, Cosmoceras, Œcotyphius.* Of these genera one is new, namely, *Bajocia*, founded on an unique specimen; and it must be confessed that the example is sufficiently distinct in every way to warrant this treatment. Although the author does not say so, it is evident the genus belongs to the subfamily Sonniniæ; and M. Brasil practically admits as much when he states that it is very near to *Dorsetensia*. He further says that he considers it to be a branch from *Haplopleuroceras*, whose representatives have lost not only the two rows of spines, but even the keel and the furrows. We find ourselves unable to agree with this opinion, because the periphery is rounded and flattened; in our experience the keel and furrows do not disappear without leaving some trace of their former existence on the configuration of the periphery. We agree with the author that *Bajocia* is near to *Dorsetensia*, and we are inclined to think it is a late-surviving example of the stock whence *Dorsetensia* originated, and a "cousin" of *Zurcheria*.

Besides the new species, M. Brasil is able to give us descriptions, and in some cases figures, of previously described forms; and in all this work he adds to our knowledge of Jurassic Ammonites, and deserves our thanks.

We find that M. Brasil has carried into effect a suggestion which we made a few years ago. We wrote ("Bajocian of the Sherborne District": Q.J.G.S., vol. xlix, p. 483) concerning the use of the name *Humphriesianus* for chronological purposes—"The confusion concerning this specific name and the large number of species of *Stephanoceras* make this appellation very unsuitable. It would be desirable to apply the name of a species belonging to a less prolific genus." M. Brasil makes very similar remarks concerning the confusion, and then says—"It appears to us that *Dorsetensia Edouardiana* ought to replace *Ammonites Humphriesianus*." Whether this will free us from the confusion, or will only introduce another, remains to be seen. We remember that, unfortunately, our own identification of *D. Edouardiana* has been challenged, whether rightly we will not pretend to say, without an extended comparison of our specimens with the actual type, because it seems that the original figure is not altogether reliable.

In this matter of draughtmanship have arisen most of the troubles

[1] Extrait du Bulletin de la Société géologique de Normandie, tome xvi, 1892–3 (published 1896).

of identification. M. Brasil has attempted to diminish error by the application of photography to the production of his plates. Herein it seems to us that the results are not quite so successful as they should be, and as they can be made. From our own experience of photographing Ammonites we can tell him that orthochromatic plates destroy all those differences due to diverse colours of the matrix or test, and thus dark or light stains on the fossils do not give the false suggestion of furrow or rib. We give this hint because we are convinced that photography, rightly applied, is *the* medium for palæontological illustration.

The other pamphlet alluded to is the second part of that important work by Dr. J. F. Pompeckj, entitled "Beiträge zu einer Revision der Ammoniten des Schwäbischen Jura."[1] Two genera are dealt with—namely, *Lytoceras* and *Ectocentrites*. The author notices that from *Lytoceras*, as previously constituted, six already-named genera, of which *Ectocentrites* is one, may be sheared off; and then that *Lytoceras* is divisible into three groups—1, of *L. fimbriatum*; 2, of *L. Villæ*, Meneghini; 3, of *L. articulatum*, Sow. In these groups the author describes several new species, and gives important correction in regard to others; for instance, what we have long had in mind to do, the correction of the synonymy of *Lytoc. cornucopiæ*, Young and Bird—that this species=*Lytoc. Siemensi*, Denckmann, and is not *cornucopiæ*, Wright; and as we have said before this, not D'Orbigny's. For such work as this the author deserves our thanks; it is most necessary. Herein we may draw attention to one matter which has, in connection with other species, puzzled even English authors—that there were two editions of Young and Bird's work, one published in 1822, the other in 1828, *and that the contents of the plates differ considerably.*

In one matter we have to correct Dr. Pompeckj. He speaks of *Lytoc. confusum*, Buckman, as not figured, and that it may well be nothing else than *Lytoc. trapeza*, Quenst. But it is figured, namely, in 1883, in Proc. of Dorset Nat. Hist. Field Club, vol. iv, pl. iii, figs. 1, 2, along with ten other new species. It would, therefore, take precedence of *trapeza*, if they were the same: but they are not, as we have stated in the pages of this Journal (Vol. IX, p. 260, 1892). They lived, too, at different dates—*confusum* in the hemera *concavi*, *trapeza* two hemeræ later (Sonniniæ). We may remark that at one time the deposits of these dates were all called *Sowerbyi*-zone; but the separation of the *concavum*-zone from the *Sowerbyi*-zone has been pointed out some time.

VII.—On Plant Beds of Tertiary Age in British Columbia.

By Geoffrey F. Monckton, Esq.

THE following notes refer to the fossils found by me, during the last two years, in the Tertiary strata of Burrard Inlet, British Columbia, and to the enclosing rocks themselves. These fossils were derived from beds outcropping within four miles of the city of Vancouver. The strata consist of sandstones, mudstones, shales, and

[1] Stuttgart. E. Schweizerbart'sche Verlagshandlung, 1896, pp. 95–178, pls. viii–xii.

thin, irregular beds of lignite, of which last-named material a typical analysis by me gave—fixed carbon, 36·10; volatile combustible matter, 41·25; ash, 15·40; and hygroscopic water, 7·25 per cent. These lignite beds usually are only about an inch in thickness, but sometimes they run into pockets a foot or more in depth. There has been a considerable amount of money spent in putting down boreholes in this district in search of workable coal-seams, but, so far, without success; and the opinion of the writer is that no workable coal beds exist there, unless they occur in the Cretaceous beds, which are the coal-bearing deposits of Western North America, and probably underlie these strata. Early in 1894 I found the bed from which my earlier specimens were obtained. The lower part of this contains aquatic plants; above these are palm-leaves; and, again, above these salix, populus, and juglans (willows, poplars, and hickory). In the highest part of the deposit are palms and a few other leaves. The whole bed varies from four to eighteen inches in depth, and is underlain by a few inches of black shales, which contain many leaves that are for the most part very difficult to distinguish. This shale thins out in a few yards, and it would seem that the fossil bed runs out at the same point where the shale vanishes. I think that probably there existed, at the time when these fossils were deposited, a cove at this point, where the water was slack. The second bed which I worked in produces fewer fossils, but the veining is much more distinct. This deposit was only found in May, 1895. Where it was first opened the total thickness did not exceed one inch, which contained leaves of angiosperms, underlain by about one inch yielding fern-leaves. Underneath it was a bed of black shale two inches thick. Where it is now worked the upper part is at least six inches thick. It is curious to note in this deposit how at one end the hickory prevails; in the middle, poplars and willows; and at the other end, poplars alone: which would seem to point to the fact that these leaves were not carried any distance, but lie where they fell from trees overhanging the bank.

I might preface the description of my fossils with some remarks as to the supposed age of these rocks. To the southward is a region covered with strata which are of the same age, and are now generally supposed to be Eocene, and compared to the Upper Laramie. The Laramie formation is to be adjudged as belonging to the Eocene, if its age be determined by the fossil leaves which it contains. It is identified, however, by its saurian remains, and also by the occurrence of some mollusks with the Cretaceous. It passes down into the Cretaceous without any stratigraphical break, while the overlying Tertiary are, as a rule, unconformable to it. Heer classed it as Miocene, Lesquereux partly as Eocene and partly as Miocene, while Clarence King referred part of it to the Cretaceous. It has recently been found to underlie Miocene beds, which would seem to stamp the upper part as Eocene.

Some of the species found point to a considerably warmer climate than that which now prevails at Burrard Inlet, which resembles the south of England, although others are very similar to plants which grow there at the present time.

One of the most common forms found has been the leaf of a Sabal, which has been referred by Sir J. W. Dawson to *Sabal Campbellii*. The specimens submitted to him show about twelve parallel veins on each slope of the folds, at six inches from the base of the leaf. One fragment is apparently a portion of a leaf five feet in diameter. There are also fragments which indicate a pinnate palm-leaf referred to *Manicaria*.

Populus balsaminoides occurs very frequently. Although Sir J. W. Dawson has referred some leaves to this species, he points out that they do not possess the serrated edges peculiar to it. These leaves are often six inches across. Of willows, *Salix integra* and *Salix varians* are common; but the venation of these leaves is usually very indistinct, although one or two specimens which have been obtained show it very clearly.

Platanus is represented by a few large leaves. These are very common in the Laramie strata, which cover much of the interior of British Columbia. One specimen of *Æsculus* has been found by me, and Sir J. W. Dawson has named it *Æsculophyllum Hastingsense*. The specimen is not very distinctly defined. The bases of seven leaves which are articulated to a common petiole are shown.

In some places the leaves of the hickory occur in great profusion, and have been named *Juglans denticulata*. The same species occurs in the Eocene of Greenland. A fruit which was first discovered by Mr. Hill Tout, of Vancouver, and was afterwards found by the writer, has been named provisionally *Carex Burrardianus*. Leaves of the genus *Carex* have previously been found in this district. Several leaves referred to *Quercus* are found in the beds. A very large number of specimens of the fern *Lygodium neuropteroides* occurs, some layers being composed entirely of these. Among others, *Ficus Shastensis* (Lesq.), *F. Condorii* (Newberry), *Quercus Evansii* (Lesq.), *Sequoia spinosa* (Newberry), and *Dryophyllum*, are found. Impressions of a matted growth of aquatic plants occur at one point.

I had prepared a number of tracings from drawings of specimens in my collection to illustrate these notes.[1] The specimens are named by Sir J. W. Dawson, but some are not yet identified.

The strike of the beds from which the fossils were taken is very irregular, but is roughly S.W. and N.E., the dip being about 18° to the S.E., which would seem, so far as my explorations have yet gone, to bear some relation to basalt dikes, the trend of which is along the line of strike.

In conclusion, I may say that there has been but very little work done on these beds, the workers being very few in number; and we should be glad to have the co-operation of others. Some of my specimens have been described and figured by Sir William Dawson in a paper on collections of "Tertiary Plants from the vicinity of the City of Vancouver, B.C.": Trans. Roy. Soc. Canada (1895-6), vol. I, sec. iv, p. 137.

[1] These tracings (in the absence of the original specimens) were not deemed sufficient to enable the artist to prepare a plate by; they have therefore not been used to illustrate the paper.—Edit. Geol. Mag.

VIII.—On the Occurrence of the Genus *Listracanthus* in the English Coal-measures.

By Herbert Bolton, F.R.S.E.,
Assistant Keeper, Manchester Museum, Owens College.

DURING the last few months two spines, or Ichthyodorulites, belonging to the genus *Listracanthus*, have come under my observation. Since both are well-preserved specimens, and not hitherto recorded from the English Coal-measures, some information as to their appearance and stratigraphical position may be of interest.

The genus *Listracanthus* was formed by Newberry and Worthen[1] in 1870 to include small spines found in the Coal-measures of Illinois. These spines are small flattened structures, curved backwards, and with the sides ornamented by longitudinal ridges. The convex and concave margins are provided with acute spiny denticles.

Newberry and Worthen described only one species, *L. hystrix* (*tom. cit.*, p. 372, pl. ii, figs. 3, 3*a*), to which *L. Hildrethi* was subsequently added by Newberry[2] from the Coal-measures of Ohio, and *L. Beyrichi*[3] by A. von Könen from the Coal-measures of Herborn, Nassau. An undescribed species is also recorded by A. Smith Woodward[4] from the Calciferous Sandstone of East Kilbride, Lanarkshire; while others from the Upper Carboniferous Limestone Series of Belgium are noted by L. G. de Koninck.[5]

The larger of the two Lancashire specimens was found by me amongst the geological collections of the Royal Museum, Peel Park, Salford, when I was engaged upon their rearrangement. Although unlabelled, it fortunately happens that the spine lies upon the broken surface of an ironstone nodule, and is associated with *Goniatites Listeri*, *G. atratus*, *Aviculopecten papyraceus*, and numerous small ostracods. Ironstone nodules of this character are restricted in the Lancashire Coalfield to the roof of the Bullion or Upper Foot Mine of the Lower Coal-measures; hence the horizon of the specimen can be exactly determined. The second and smaller specimen is the property of Mr. Robert Cairns, of Ashton-under-Lyne, and was obtained by him from the marine band of the Middle Coal-measures in the River Tame at Dukinfield. It is enclosed in a nodule of earthy ironstone, and is unaccompanied by other fossils. I remember finding a third specimen ten years ago in the shales overlying the Bullion Coal of the Lower Coal-measures of Bacup, but it has since been lost.

Both the specimens now to be described differ from the three species hitherto defined, as well as from one another, but it is perhaps hardly justifiable to found a species upon the smaller specimen.

[1] "Pal. Illinois," vol. iv, 1870, p. 371.
[2] Rep. Geol. Surv. Ohio, vol. ii, pt. 2, 1875, p. 56, pl. lix, fig. 6.
[3] Neues Jahrb. 1879, p. 341, pl. vii, fig. 1.
[4] Catal. Foss. Fishes, B.M., pt. 2, 1891, p. 149.
[5] "Faune Calc. Carbf. Belg.," pt. 1, 1878, p. 75, pl. v, fig. 11.

Description of Specimens.

1. *Listracanthus spinatus*, sp.n.

Diagnosis.—Spine small, not exceeding 19 mm. in length, gently arched, sides flat, with seven longitudinal ridges, the convex and concave margins bearing acute spine-like denticles. The denticles of the convex margin few in number and placed at equal distances apart, these pointing a little forwards and upwards, and the angle which they make with the margin being not more than ten degrees. Only three denticles shown, but a fourth probably given off just above the broken upper edge. The first lateral ridge directly prolonged into the lowest denticle of the convex margin, the second ridge giving origin to the second and third denticles, and probably continuing upwards to a fourth (though a slight dislocation of the spine at this point prevents a clear determination). The denticles of the concave margin larger, stronger, and more numerous than those of the convex margin, and directed outwards at an angle fully double that of the latter. A cluster of five spines placed at the base, in fan-fashion, the margin spreading out between them like a web.

Listracanthus spinatus, sp.n. Lower Coal-measures, Lancashire.

Above the cluster are nine others at increasing distances apart. The lateral longitudinal ribs seven in number at the base, but only four continuing up to the broken apex, the remaining three running out into the denticles; all showing traces of slight nodular enlargements.

Observations. — The species thus described differs in several respects from all the known species, and is well characterized by the differences of the denticles of the concave and convex margins, the slight nodulation of the lateral longitudinal ridges, and the fan-like expansion of spines at the base of the concave margin.

Horizon.—Roof of Bullion Mine, Lower Coal-measures.

Locality.—Lancashire.

Type in the Royal Museum, Peel Park, Salford.

2. *Listracanthus*, sp. indet.

Description. — Spine small, not exceeding 11 mm. in length, arched, sides flat, with nine longitudinal ribs. Concave margin only bearing denticles, which are small, about twelve in number, and closely set. Convex margin entire.

Observations.—This specimen differs in several important features from *Listracanthus spinatus*. It is shorter, more arched, and broader in comparison to the length, whilst only the concave margin bears denticles. So little is known of the nature and position of the two spines, that it may possibly be that the differences between them are only due to the position they occupied upon the body, and not to specific difference. Against this view must be placed

the fact that one spine belongs to the Lower and the other to the Middle Coal-measures.

Horizon and Locality.—Marine band, Middle Coal-measures, River Tame, Dukinfield.

In conclusion, I desire to record my indebtedness to Mr. A. Smith Woodward, who first recognized the specimens as belonging to the genus *Listracanthus.*

REVIEWS.

I.—The Scenery of Switzerland and the Causes to which it is due. By the Right Hon. Sir John Lubbock, Bart., M.P., F.R.S., D.C.L., LL.D., F.G.S. 8vo, pp. xxxvi and 474, with 154 illustrations in the text and one folding map of Switzerland. London: Macmillan and Co. (Limited), 1896.

THIS book, which was issued in July last, will have already found its way into many an Alpine tourist's knapsack, and been read with pleasure in railway-train, or steam-boat, and in many a Swiss hotel and chalêt, by mountain and lake.

Its author's varied writings are already agreeably known to and welcomed by many thousands of our fellow-countrymen, both here and in greater England beyond the seas.

Whatever subject Sir John Lubbock takes up, he has the facility to communicate the results of his studies, his readings, and his observations, in an agreeable form to the public at large, who are only too delighted to be told facts in natural history, geology, or physical geography in clear and simple language, so that the reader need not fear to be carried beyond his depth by a too learned treatise, or told mere second-hand twaddle by an incompetent but too officious guide.

Sir John Lubbock is no mere tyro as a travelling companion to the Swiss Alps. He tells us, that as long ago as 1861, he had the pleasure of spending a short summer holiday in Switzerland with Huxley and Tyndall, and that from that day to this many of his holidays have been spent in the Alps. "On them," he adds, "I have enjoyed many and many delightful days; to them I owe much health and happiness. . . . . My attention was from the first directed to the interesting problems presented by the physical geography of the country. I longed to know what forces had raised the mountains, had hollowed out the lakes, and directed the rivers."

The author read much of what has been written about them; but, like all students, he wanted some book which should give him a short, comprehensive statement of the views of the various great authorities who had devoted their lives to the unravelling of the vast problems of the structure of the Alps, which might be useful to those travelling in Switzerland; but no such handy book was available.

At last, after much hesitation, Sir John Lubbock resolved to write such a work as he had himself felt the need of in the past, and so set to work, aided by such valuable help as could be obtained from Professor Heim, Sir John Evans, and others, and by making

careful studies of all the literature available, he has given to the inquiring Briton, who, bent on spending his summer holidays in a clamber over glaciers and snowfields to reach some lofty peak, is curious to know how the mountains were brought forth, and how the hills and the dry land were formed. For such this book will be a most acceptable offering; replete as it is with keys to unlock the many geological puzzles which the Alps afford. Nor need he be surprised to find that more than a hundred able and accomplished men of science in England, France, Germany, Austria, Switzerland, and Italy have laboured to provide the plans and explanations, the pith of which Sir John Lubbock has given us in a condensed form in the little book before us. In concluding his task, the author thus summarizes the causes which have led to the present scenery of Switzerland.

"In Permian times there were probably mountains where the Alps now rise, but this ancient range was gradually removed by denudation; moreover, the land sank, and during the Permian, Liassic, Jurassic, and Cretaceous periods, there was deep sea where the Alps now rise. There were certainly great changes of level, but they were all continental, and that is to say, they were approximately the same for the whole area; there was no compression and no folding.

"That the sea during this period must have covered the site of the present Alps, is proved (1) by the fact that we find no trace of its southern shores, no littoral deposits. If the Alps had then existed, pebbles, etc., from them must have been found in the Liassic, Jurassic, and the Cretaceous rocks. This is not the case: indeed, these rocks contain no pebbles of any kind, and the fossils in them are all indicative of deep water far away from land. There are no conglomerates or gravel beds between the Permian and the Upper Eocene. Again, (2) we find remains of the secondary strata protected in the troughs of the folds. These sedimentary deposits therefore extended completely over the site of the present mountains, and though no extensive remains of these deposits now occur in the Central Alps, this is because they have been entirely stripped away.

"The elevation of the country is due, not to upheaval from below, but to lateral pressure owing to the cooling and consequent contraction of the earth. It has been calculated that the strata between Basle and Milan, a distance of about 130 miles, would, if extended horizontally, occupy 200 miles. There has consequently been a shortening of no less than 70 miles.

"For some time the central ranges alone were above water, and the mountain torrents brought down gravel and boulders, forming the 'Nagelflue' of the Rigi and the central plains.

"The Alps, therefore, from a geological point of view, are very recent. Our Welsh hills, though comparatively speaking insignificant, are far more ancient. They had been mountains for ages and ages before the materials which now compose the Rigi or the Pilatus were deposited at the bottom of the sea. Indeed, we may

say that it is because they are so old that they have been so much worn down; the Alps themselves are crumbling, and being washed away; and if no fresh elevation takes place, the time will come when they will be no loftier than Snowdon or Helvellyn.

"They have already undergone enormous denudation, and it has been shown that from the summit of Mont Blanc some 10,000 to 12,000 feet of strata have been already removed. The conglomerates of Central Switzerland, the gravels and sands of the Rhine and the Rhone, the Danube and the Po, the plains of Dobrudscha, of Lombardy, of South France, of Belgium and Holland, once formed the summits of Swiss mountains. This amount of denudation gives us, I will not say a measure, but at any rate a vivid idea of the immense time that must have elapsed since the Alps rose out of the sea.

"Denudation began as soon as the land rose above the sea; the main river valleys were excavated. Then came the period of cold known as the Ice Age or Glacial period.

"Round all the high mountains, and over many of them, are great fields of ice and snow, terminating in glaciers. These, however, are but the remnants of a much larger sea of ice which once covered almost the whole country. The glacier of the Rhone, for instance, descended the Valais, filled the Lake of Geneva, rose to what is now a height of 1350 metres on the Jura, and then dividing, sent one branch as far as Lyons, and a second along the Aar to Waldshut. The Glacial period, however, was not continuous, but interrupted by at least two periods of more genial climate. The mass of material brought down from the mountains partially filled the river valleys (which have not even yet been entirely re-excavated), formed great moraines, and is spread in thick but irregular masses over all the lower ground.

"The rivers of Switzerland run mainly in one of two directions—the first from south-west to north-east, or *vice versâ*, following the strike and original folds of the strata; and the second at right angles to it. Many, indeed most, of the principal rivers, take first the one and then the other direction in different parts of their course. In some cases the rivers cut through mountain ranges, as, for instance, the Rhone between Martigny and the Lake of Geneva. This probably indicates that the river is older than the mountain range, and cut through it as it rose.

"The river system of Switzerland was, however, at first very different from the present. The Vosges and the Black Forest were continuous, the subsidence which now separates them not having yet taken place, so that the Rhine Valley at Basle was not in existence.

"Nor had the gorges by which the Rhone finds its exit through the Vuache yet been formed, and the consequence was that the whole drainage of Switzerland north of the Alps found its way by the Danube to the Black Sea. For some time after the subsidence of the Basle Valley had taken place the upper waters of the Rhone still joined the Rhine, and ran over the plains of Germany to the North Sea; finally, however, it broke its way by Fort de L'Ecluse, and falling into the Saône runs into the Mediterranean. Another

general change in the river system is that the crest of the Alps has retreated northwards. The southern slope being much steeper than that to the north, the Italian rivers have more power of erosion than their northern rivals, and are gradually eating their way back. The Upper Engadine is a conspicuous example.

"Many minor changes have taken place: partly (1) through recent changes of level, as, for instance, that which has diverted the Reuss from its old course by the Lake of Zug, and driven it round by Lucerne; partly (2) by rival rivers deepening and extending their valleys, and thus annexing territory which previously belonged to others; for instance, the Landquart has robbed the Landwasser of its head waters and carried off the Schlappina, the Vereina, and the Sardasca; partly (3) by dams due to river cones or glacial moraines, as, for instance, the Limmat, which was driven from the Glatthal and the Sihl from the Valley of the Lake of Zurich.

"The lakes which contribute so much to the beauty of the country fall into several different categories.

"1. Some are due to the inequalities in the glacial deposits; as the numerous small pieces of water in the curious district of the Pays de Dombes.

"2. Some are due to subsidence; strata, generally those of gypsum or salt, having been dissolved and removed; as, for instance, the lakes of Cadagno and Tremorgia.

"3. Some are dammed back by river cones, as the lakes of the Upper Engadine; or by moraines, as the lakes of Sempach, Baldeggar, and Hallwyl.

"4. The origin of the larger Swiss lakes has been the subject of much discussion. The opinion now prevalent among Swiss geologists is that they are mainly due to recent changes of level, and are in fact drowned river valleys.

"Even more striking than the exquisite beauty of the lakes is the grandeur of the history they unfold, and of the causes to which they are due; and, indeed, in contemplating the general scenery of Switzerland, we cannot but be profoundly impressed by the enormous magnitude of the changes, and the irresistible forces which have been brought into operation."

We have been tempted to quote perhaps too largely from this very interesting summary. To those who are attracted by this notice we would say, "Get the book and read it for yourselves." It is just of a handy size to put into one's haversack and take as a useful companion to Switzerland. The illustrations are very numerous, and many of them are excellent from a geologist's point of view.

II.—Essai de Paléontologie Philosophique. By Professor Albert Gaudry, Memb. Inst. France, For. Memb. Geol. Soc. London. Paris, 1896. (Dulau and Co., London.)

THIS volume forms a supplement to the distinguished author's well-known work "Enchainements du Monde Animal dans les Temps Géologiques": in it the facts and arguments brought forward in his previous volumes are correlated, and an attempt is made to

give a general idea of the course followed in the evolution of the animal kingdom from the earliest times to the present day.

This progressive advance is compared by the author to the changes passed through in the development of an individual man, and in the successive chapters of his work he considers (1) the multiplication of beings, (2) their differentiation, (3) their increase in size in the course of geological time, (4) the progress of activity, (5) the progress of the perceptive faculties, (6) the progress of intelligence.

In the chapter dealing with the multiplication of animals, it is asserted that the number of organisms has increased successively from the Cambrian onwards, and that this increase was facilitated by the fact that the earlier forms were more strongly armoured than the later ones, and at the same time were less exposed to attack. That there has been an enormous increase in the forms of animal life is, of course, obvious, but that the fossils of the earlier rocks give any idea of the richness of the contemporary faunas is more than doubtful, since it is to the fact of their well-developed skeletons that these fossils owe their preservation, while doubtless innumerable forms must have existed in which the hard parts were little or not at all developed, and of these scarcely a trace remains. Again, if the earlier types were less exposed to attack, it is difficult to understand why in the greater number, according to the author, the means of defence should have been brought to so high a state of perfection.

In the chapter on the increase of size in animals, still pursuing the comparison with the life of the individual, it is stated that there has been a gradual advance in this respect from first to last. This, again, hardly seems borne out by the facts, for if we take almost any group of animals we find that though for a time the bulk may have increased, a maximum is arrived at, at different periods in the different classes, after which a diminution sets in. In the Amphibia, for example, this maximum was reached in the Trias, while the largest reptiles were Jurassic. The Mammalia, it is true, having been evolved later in time than any other group of the Vertebrata, may be said truly to have attained their maximum development to-day in the living Cetacea, hugest of all moving creatures that breathe, and it needs but small prophetic wisdom to see the rapid disappearance of these, and, indeed, of *all the larger mammals* within the next few years, annihilated everywhere by the advance of man the destroyer. Of the larger forms the horse, cow, and sheep will soon alone survive, and even the horse may succumb before the motor-car and the bicycle! In the invertebrates the same phenomenon may be observed; for instance, the gigantic *Pterygotus* of the Silurian and Devonian periods, is unsurpassed in bulk by any recent Crustacean. The later chapters dealing with the progress of the perceptive faculties and of intelligence will meet with fewer objections, but even here the generalizations will not always hold if an attempt be made to apply them to particular cases.

The pages on the utility of palæontology to the stratigraphers are perhaps the most interesting in the book, but it seems hard to think that it should be found necessary nowadays to employ elaborate

arguments to prove the extreme value of fossils in stratigraphical work; but such is the case.

In conclusion, the writer passes beyond the realm of palæontology to the consideration of the origin of the higher faculties of man and of the prime cause of evolution, questions upon which the author's views may perhaps not be received altogether with general assent; but these need not be touched upon here.

On the whole this book is admirably and clearly written. There are many points of deep interest which are discussed in a lucid, if not alway convincing manner; and as an introduction to the outlines of palæontological history for general readers it is to be highly commended, especially as it is by one so distinguished and whose name is so widely known as an accomplished man of science and a most successful teacher. As in the previous volumes of the series, the illustrations and printing are most clear and excellent.

III.—Les Spirifères du Coblenzien Belge (Bull. Soc. Belge Geol., ix, pp. 131–240, pls. xi–xv, November 1895); and Catalogue Synonymique et critique des Spirifères du Devonien Inférieur (*tom. cit.*, pp. 260–288, February 1896). By Ferd. Béclard.

FOR over a dozen years Mr. Béclard has been studying the Spirifers of the Devonian—on the one hand, carefully revising the literature and comparing descriptions and figures with the specimens; on the other hand, making a scientific study of the specimens themselves with the aid of the abundant material in the Natural History Museum at Brussels, to which he is attached. The former branch of inquiry is soul-wearying, thanks to the vagaries of previous authors; the latter branch is not easy, owing to the remarkable extent of variation in this group, and the difficulty of obtaining specimens suitable for investigation. But both branches are absolutely necessary if the names finally attached to the specimens are to have greater value than mere dealers' labels or the haphazard shots of a schoolboy collector. In a great museum like that at Brussels, we expect that every label shall be the expression of a definite scientific opinion; for on the accessible collections of such a museum hundreds of students, geologists, and collectors depend, and rightly so, for the names of their own specimens. This fact is recognized by Dr. Dupont, and he has not grudged to Mr. Béclard the twelve years of silent but ultimately fruitful work.

Careful comparison of the Spirifers from the Coblenzian (Lower Devonian) of Belgium has convinced Mr. Béclard that though there may be scores of names in the books, and actually dozens of mutations, to which on occasion a subspecific name may legitimately be applied, yet that there are only eight distinct specific types, separated from one another without transitional forms. To these are applied the names *Spirifer primævus*, *S. hystericus*, *S. subcuspidatus*, *S. arduennensis*, *S. cultrijugatus*, *S. paradoxus*, *S. daleidensis*, and *S. Trigeri*. To these may be added *S. curvatus* and *S. speciosus*, which, however, only occur at the top of the Coblenzian, and are characteristic rather of the succeeding beds. The eight